Nissan Chemical
CORPORATION

Presentation for R&D of Performance Materials

June 21, 2022

Nissan Chemical Corporation
Performance Materials Division
Materials Research Laboratories

Translation of presentation materials for the R&D of Performance Materials held on June 21,2022

1. Business Strategy of Performance Materials Segment

Contents

FY2021
Financial Results by Segment

(¥billion)

		FY2021 (Actual) ①	FY2021 (Plan) ②	FY2021 (Actual vs. Plan) ①-②
Chemicals	Sales	37.6	43.1	-5.5
	OP	3.8	5.1	-1.3
Performance Materials	Sales	81.7	75.1	+6.6
	OP	27.7	17.3	+10.4
Agro-chemicals	Sales	65.8	70.1	-4.3
	OP	18.3	21.1	-2.8
Pharma-ceuticals	Sales	6.6	7.5	-0.9
	OP	0.9	0.7	+0.2
Others	Sales	16.3	39.2	-22.9
	OP	0.3	-1.2	+1.5
Total	Sales	208.0	235.0	-27.0
	OP	51.0	43.0	+8.0

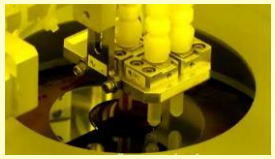
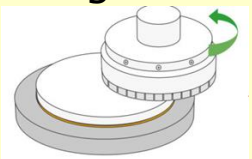
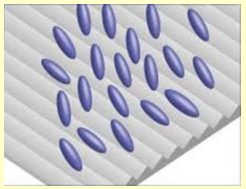
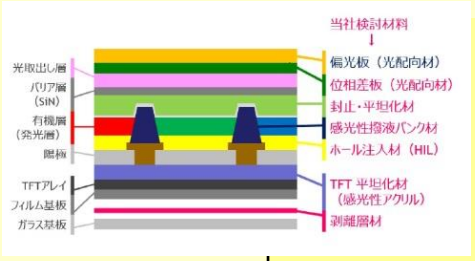
Major Difference Factors in Operating Profit

Melamine	- Lower domestic demand, export decrease, etc.
Environmental Related Products	- Sales decrease of HI-LITE, etc.
Photo IPS	- Sales increase due to widening target applications, etc.
ARC®*1	- Sales increase due to increased demand and expansion of market share, etc.
Acquired Agrochemical Products	- Sales increase due to expansion of QUINTEC(QUINOXYFEN) and DITHANE(MANCOZEB)
Fluralaner	- Sales decrease due to inventory adjustments
LIVALO	- Sales increase in domestic market
Custom Chemicals	- Sales decrease of GE API*2 - Delayed plan of peptide CMO
Adjustments etc.	- Effects of changes in accounting policies (-¥22.9 billion is included in sales of “Others”)

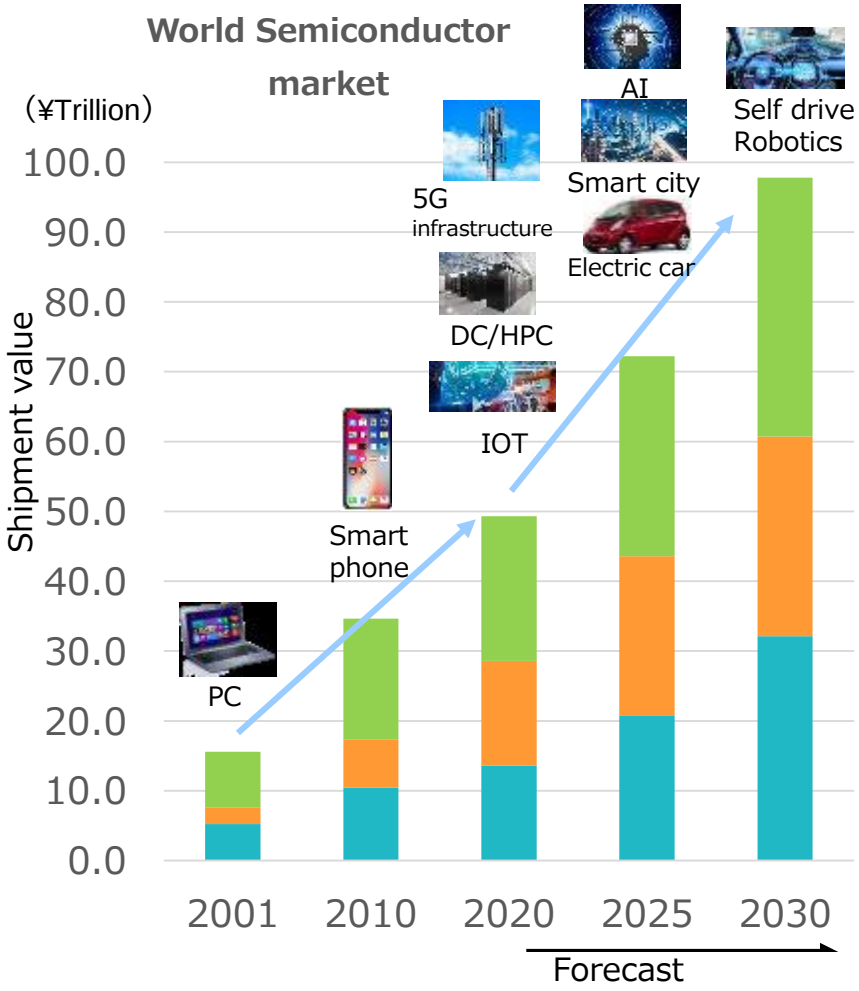
*1: ARC® is a registered trademark of Brewer Science, Inc.

Main Products and Development Products

Continue to expand the business by actively developing display related materials and semiconductor related materials.

	Main Products	Development products	R&D
Semiconductor	BARC　Multi-layer materials  Temporary bonding materials Polishing materials 	EUV-UL Image sensors materials DSA materials RDL materials	Semiconductor materials research dept. Inorganic materials research dept.
Display	LC alignment materials Photo alignment materials  Hard coating materials	OLED related materials  LCD related materials Micro LED related materials	Advanced materials research dept. Display materials research dept.

Semiconductor Field
Semiconductor Market



	Market size (2018) ¥trillion	Product example	Main company
Logic	21	Processor	intel, tsmc, QUALCOMM, NVIDIA
		GPU	
		SoC	
Memory	18	DRAM	SAMSUNG, SK hynix, Micron, KIOXIA
		NAND	
Others	15	Analogue IC	infineon, SONY, ON Semiconductor, MITSUBISHI ELECTRIC
		Power IC	
		Image sensor	

(Source) Ministry of Economy, Trade and Industry, Materials of November 2021 the 4th Semiconductor and Digital Industry Strategy Review Conference

Semiconductor Field
Execution of Capital Investment

Strengthen the production system for semiconductor materials and expand advanced evaluation functions.

1） New plant construction

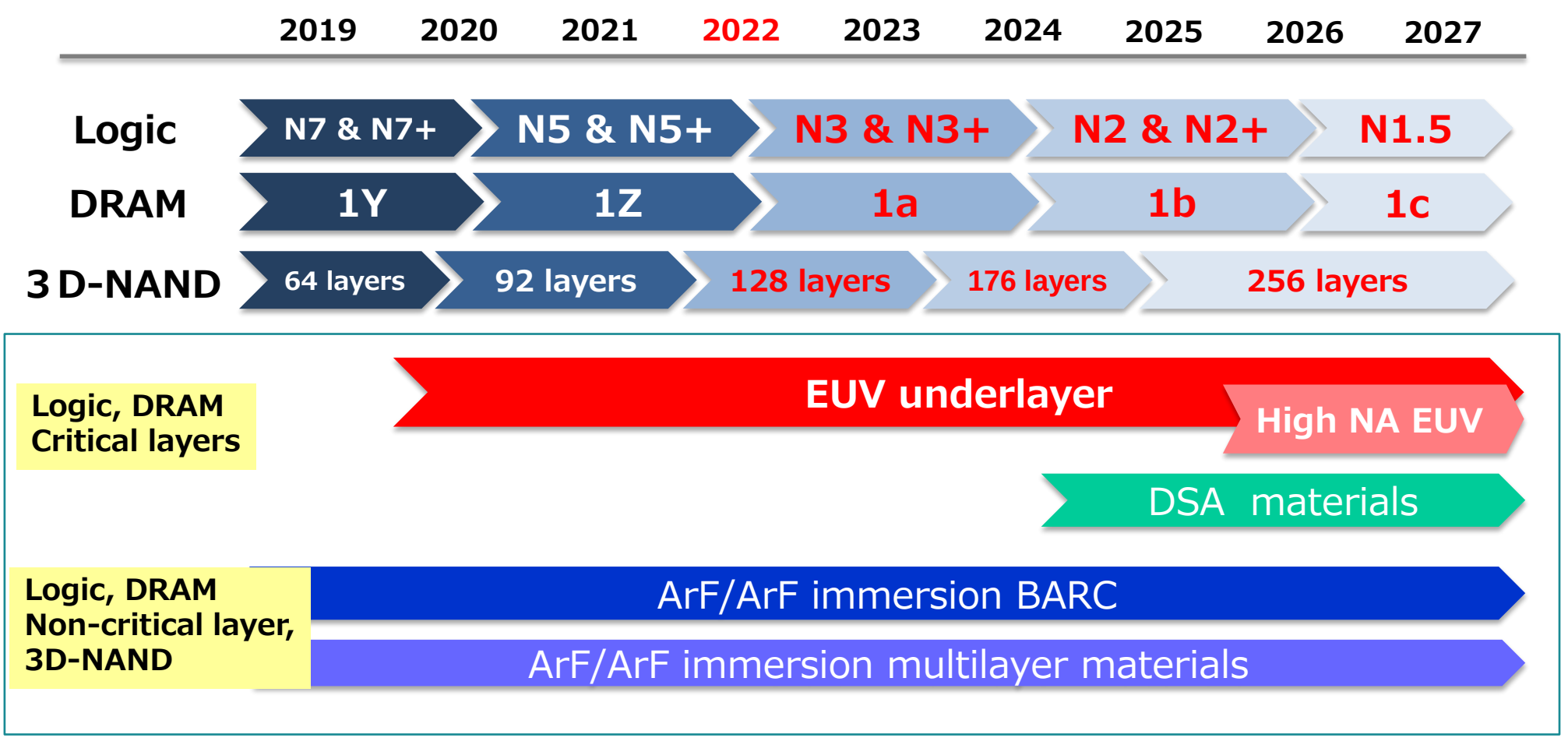
NCK Co., Ltd. 3rd plant

Place	Daxin-si Songsan 2 Industrial Complex, Chungcheongnam-do, Korea
Business	Manufacturing of semiconductor materials
Starting plan of sales operation	2024/2Q
Leasehold area	40,423m^2
Investment amount	8.5 Billion JPY

2） Capital investment

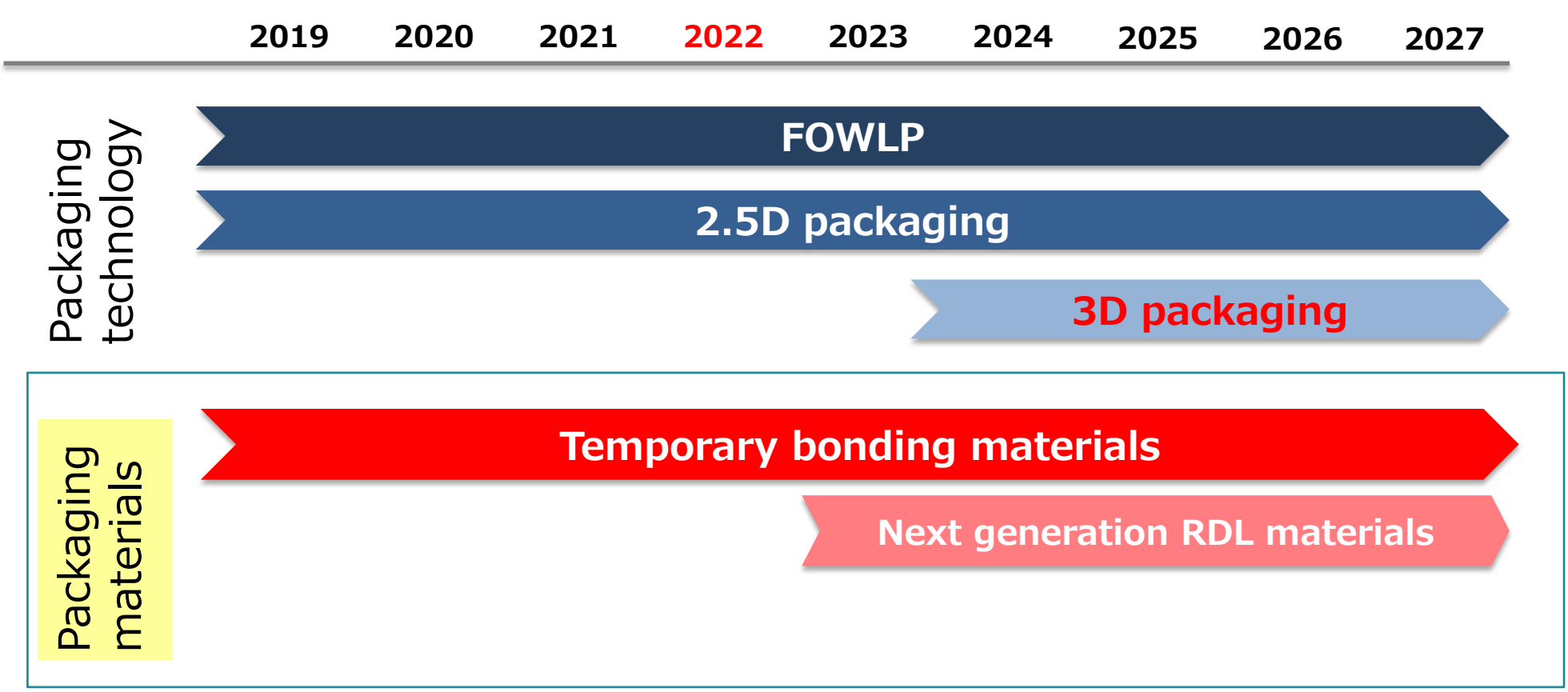
Installation of Advanced defect detection tool SP-7	Installed in 2021
Strengthening of evaluation tools	Planning in Toyama and NCK

Semiconductor Field Lithography Materials



Surely acquire next generation demands

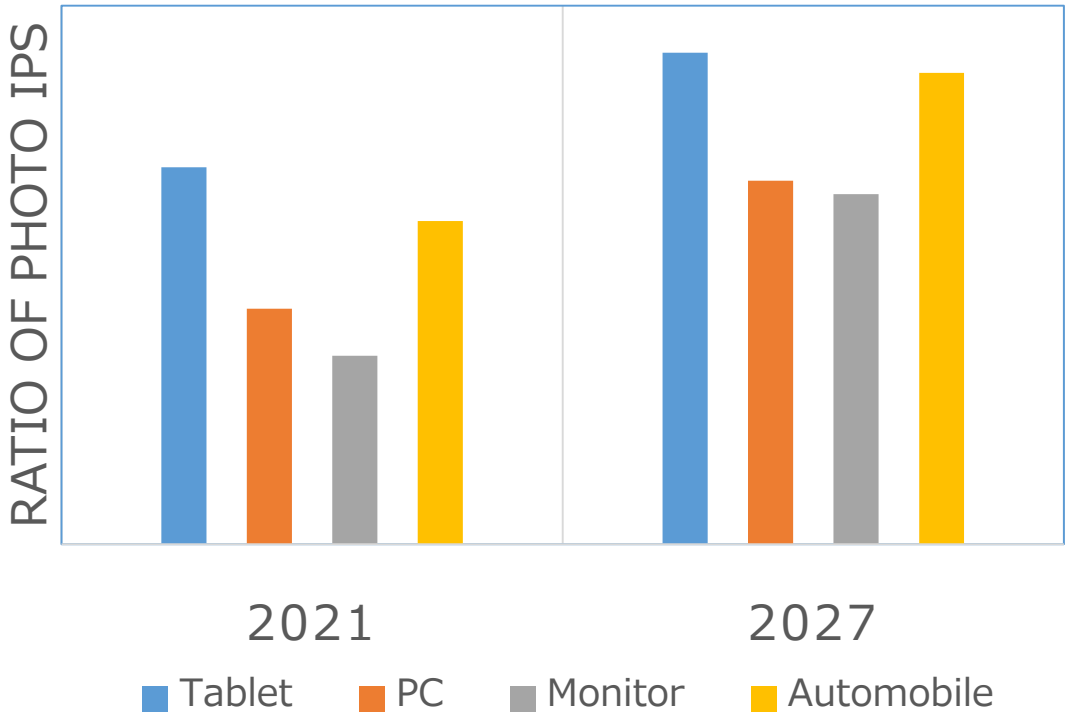
Semiconductor Field
3D Packaging Related Materials



Strengthen development of materials for next generation packaging

Display Field
Expansion of Application for Photo IPS

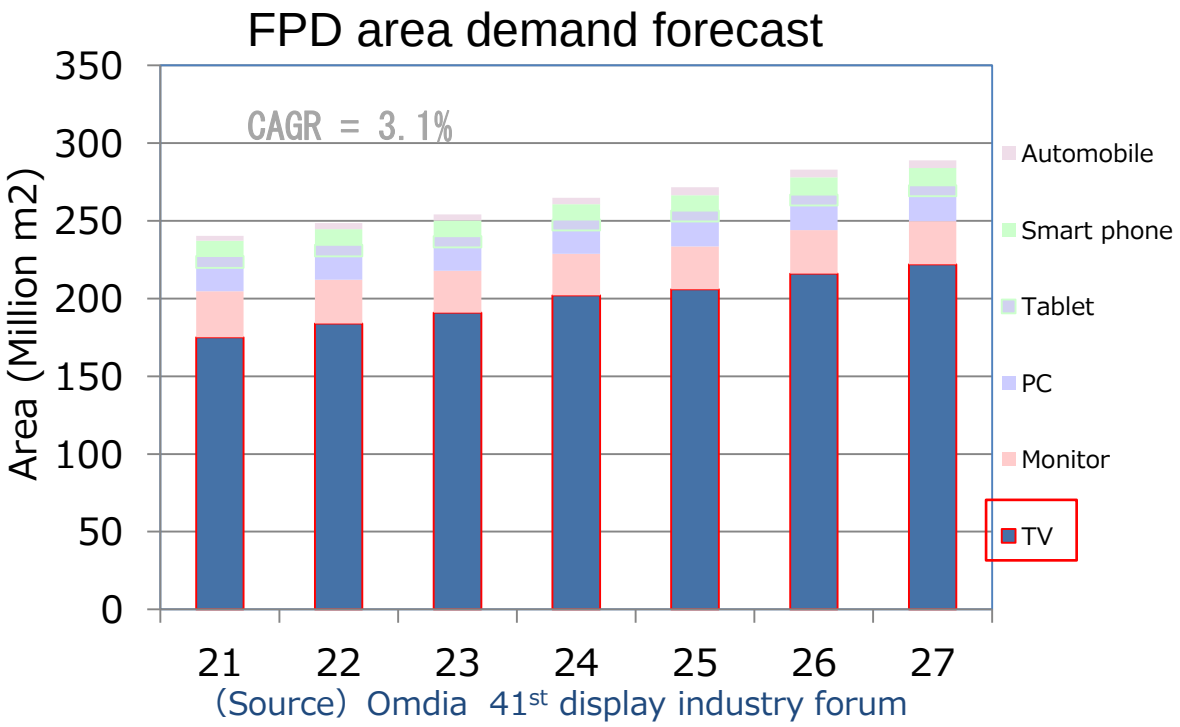
Ratio of photo IPS in each display application
(Our estimate)

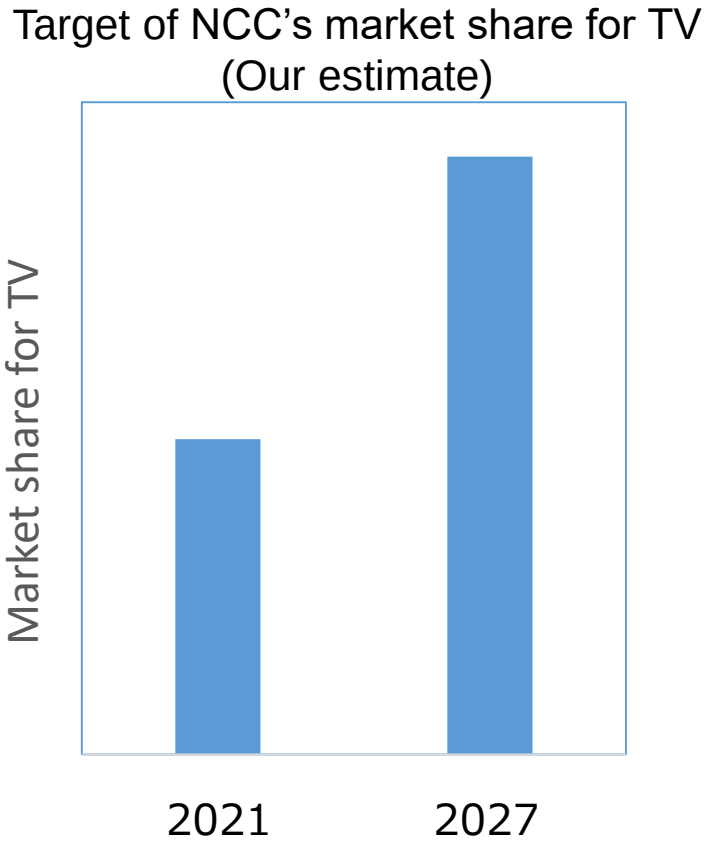


The transition from IPS (rubbing) to photo IPS is progressing, and it is expected that the applications of photo IPS will expand.

By continuously improving the characteristics, we will maintain a high market share of photo IPS and achieve the sales expansion!

Display Field
Expansion of market share of Alignment Materials for TV

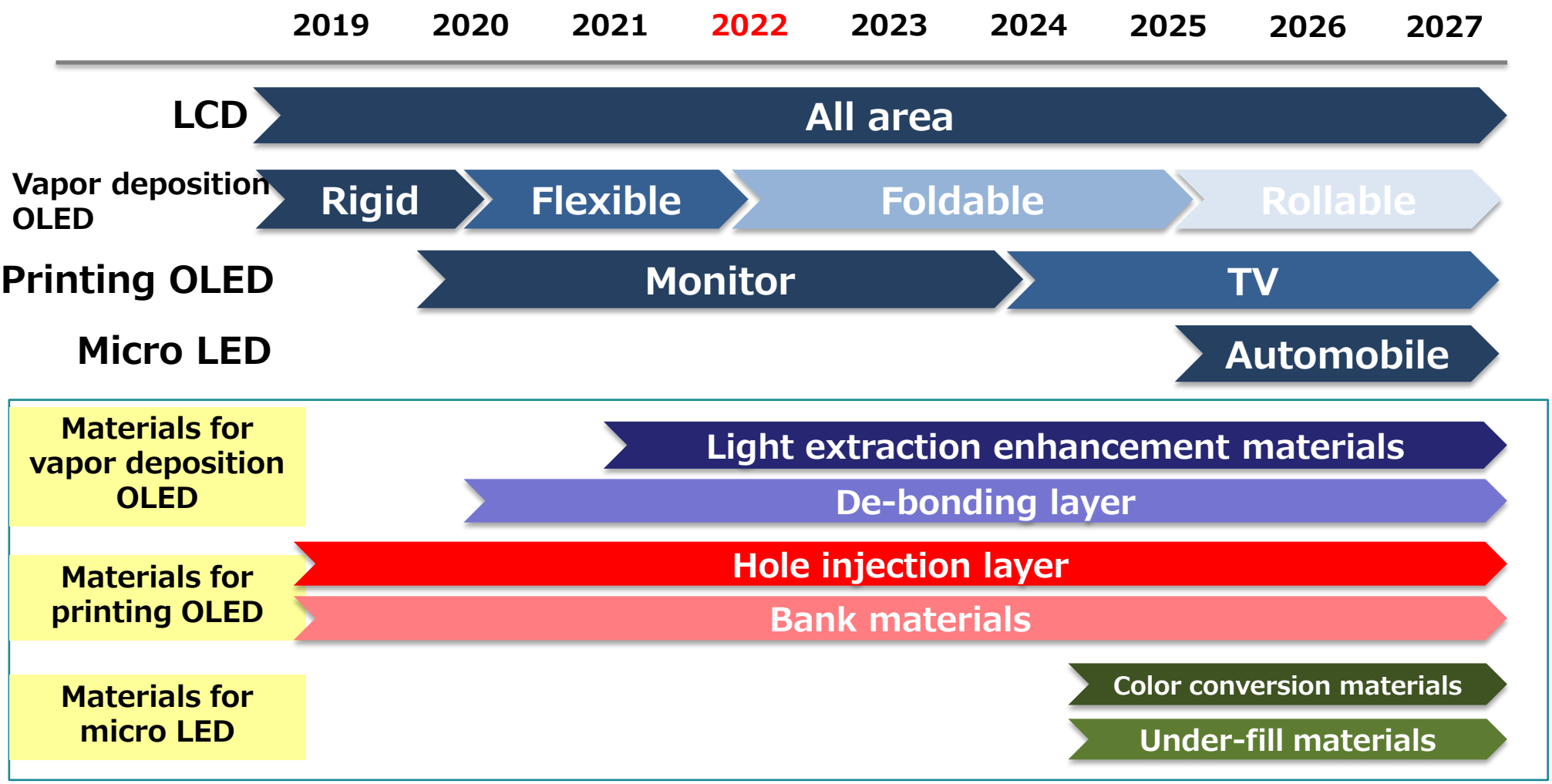




TV applications are expected to continue expanding.

Target to further sales expansion by achieving higher market share of alignment materials for TV.

Display Field
New Material Development



Proposing materials for next-generation display that are environmentally friendly

New Mid-term Business Plan

Nissan Chemical CORPORATION

Opportunities and Risks

- OLED market expansion and LCD market contraction
- Slowdown of semiconductor miniaturization and progress in 3D packaging technology
- Development of a smart society
- Intensified competition among companies

Main Measures

- Improve existing products and expand their applications
- Reinforce and increase manufacturing facilities and other facilities
- Develop and launch new products onto the market
- Start the commercial operation of the new NCK plant
- Improve profitability of the inorganic material (inorganic colloid) business

Sources of Growth

- Photo IPS
- Photo VA
- OLED materials
- Semis materials(ARC®*1, EUV materials, multi layer materials/ 3D packaging process materials)
- SNOWTEX

Major Investment Plans

- Engineering work to strengthen DP3 facility ¥0.5 billion
- Installing semiconductor evaluation equipment ¥1.2 billion
- Establishing a new NCK plant for semis materials ¥8.5 billion

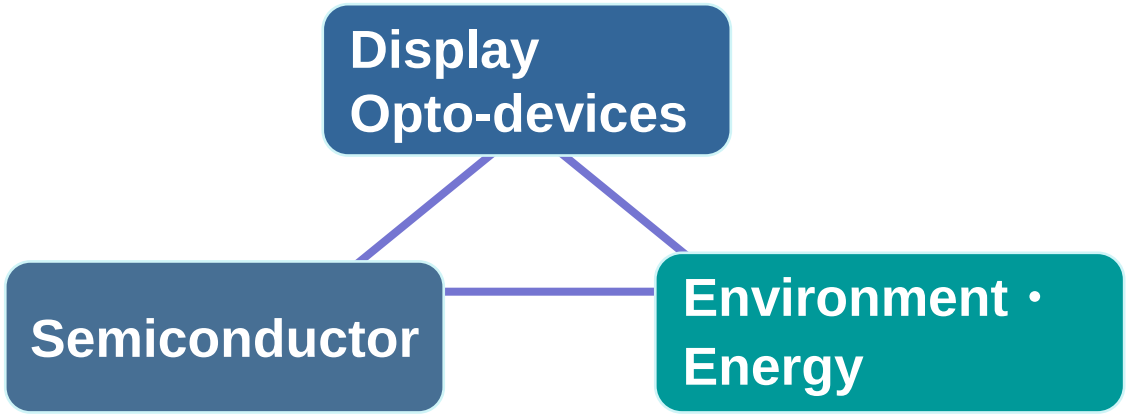
(¥billion)

	FY2021 (Actual)	FY2022 (Outlook)	FY2024 (Plan)	FY2027 (Plan)	FY2024 vs. FY2021	FY2027 vs. FY2021
Sales	81.7	89.9	102.9	117.2	+21.2	+35.5
OP	27.7	30.5	32.1	38.0	+4.4	+10.3
Capex	5.7	8.3	13.2	-	+7.5	-
Depreciation	3.9	4.7	8.7	-	+4.8	-
R&D expenses	7.0	7.8	8.9	-	+1.9	-

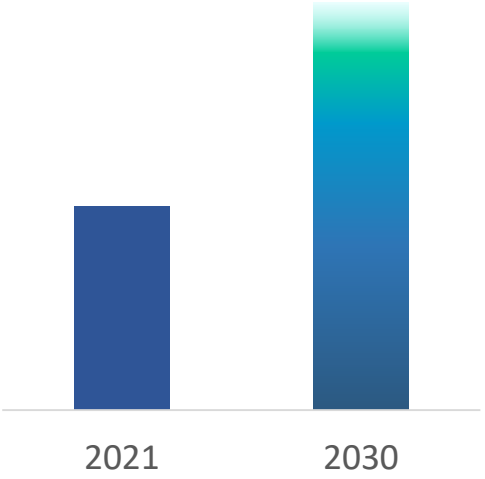
*1: ARC® is a registered trademark of Brewer Science, Inc.

How to realize our portfolio we aim for

Establish a more balanced material portfolio that can contribute to the environment as well as to the convenience of society



- Expand applications for existing products
- Promote new product development and expand the sales
- Establish new business field



2. R&D Overview for Future Growth

Contents

Introduction of Materials Research Laboratories

Nissan Chemical CORPORATION

Chiba

Chemical Research Laboratories

Funabashi

Chiba

Materials Research Laboratories

Funabashi

Materials Research Laboratories

Sodegaura

Toyama

Materials Research Laboratories

Toyama

Saitama

Biological Research Laboratories

Shiraoka

China (Suzhou)

Nissan Chemical Materials Research (Suzhou) Co., Ltd.

Korea (Pyeongtaek)

NCK Co., Ltd

Taiwan (Kaohsiung)

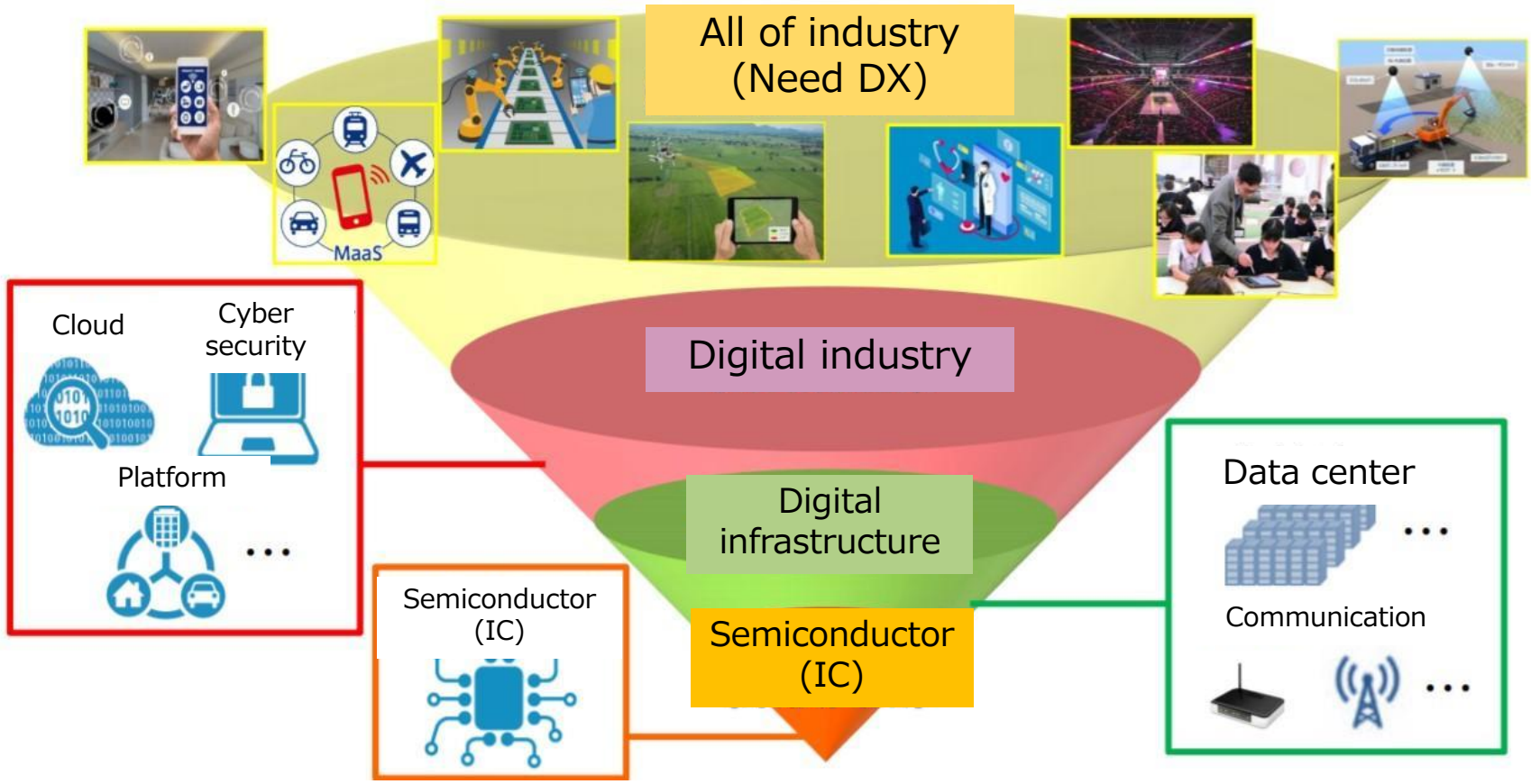
Nissan Chemical Taiwan Co., Ltd

Semiconductor Materials

Contents

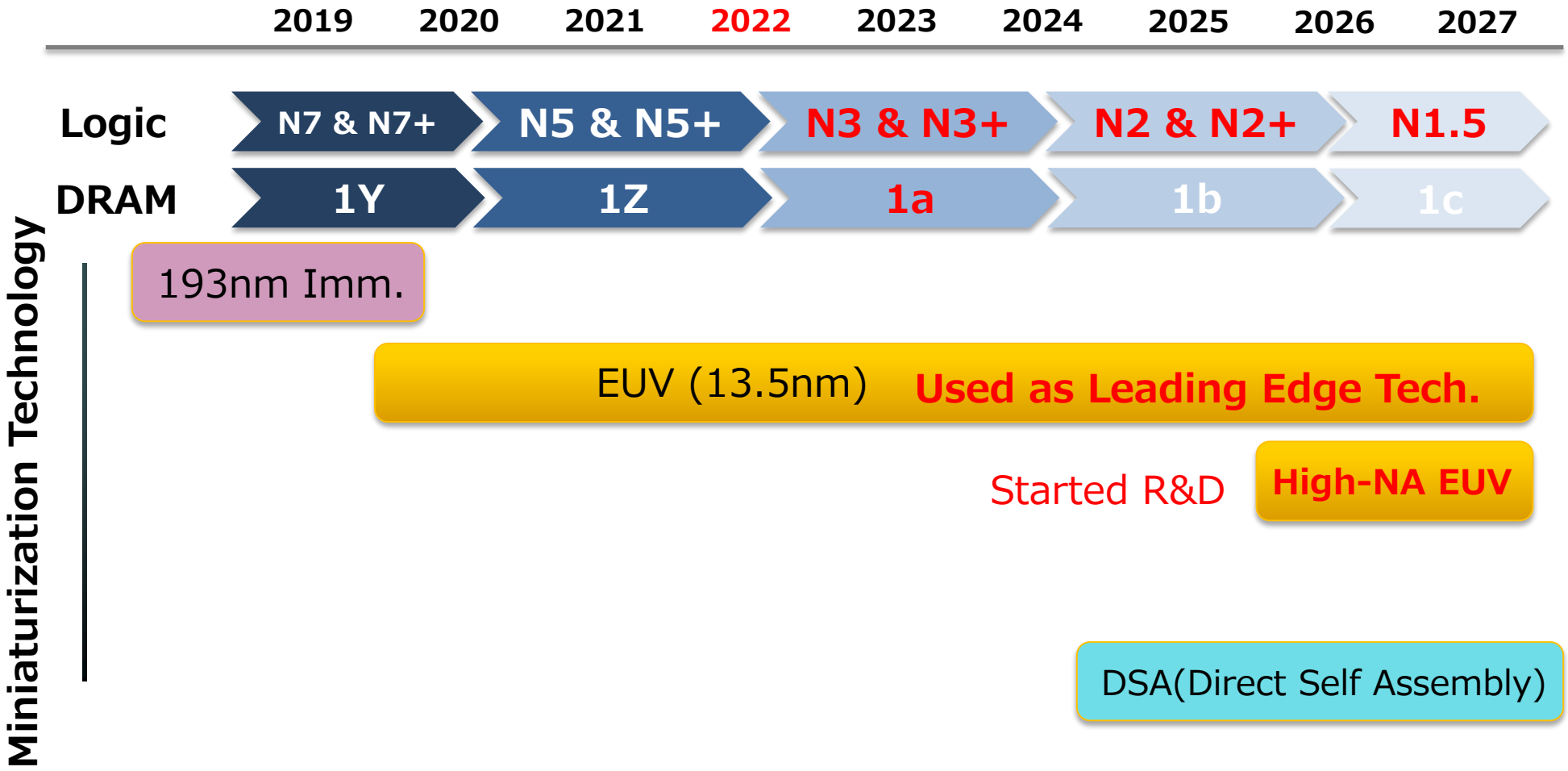
Contents

DX have been expanded rapidly because of Covid-19.
"Miniaturization and 3D packaging technology" will be strongly required.



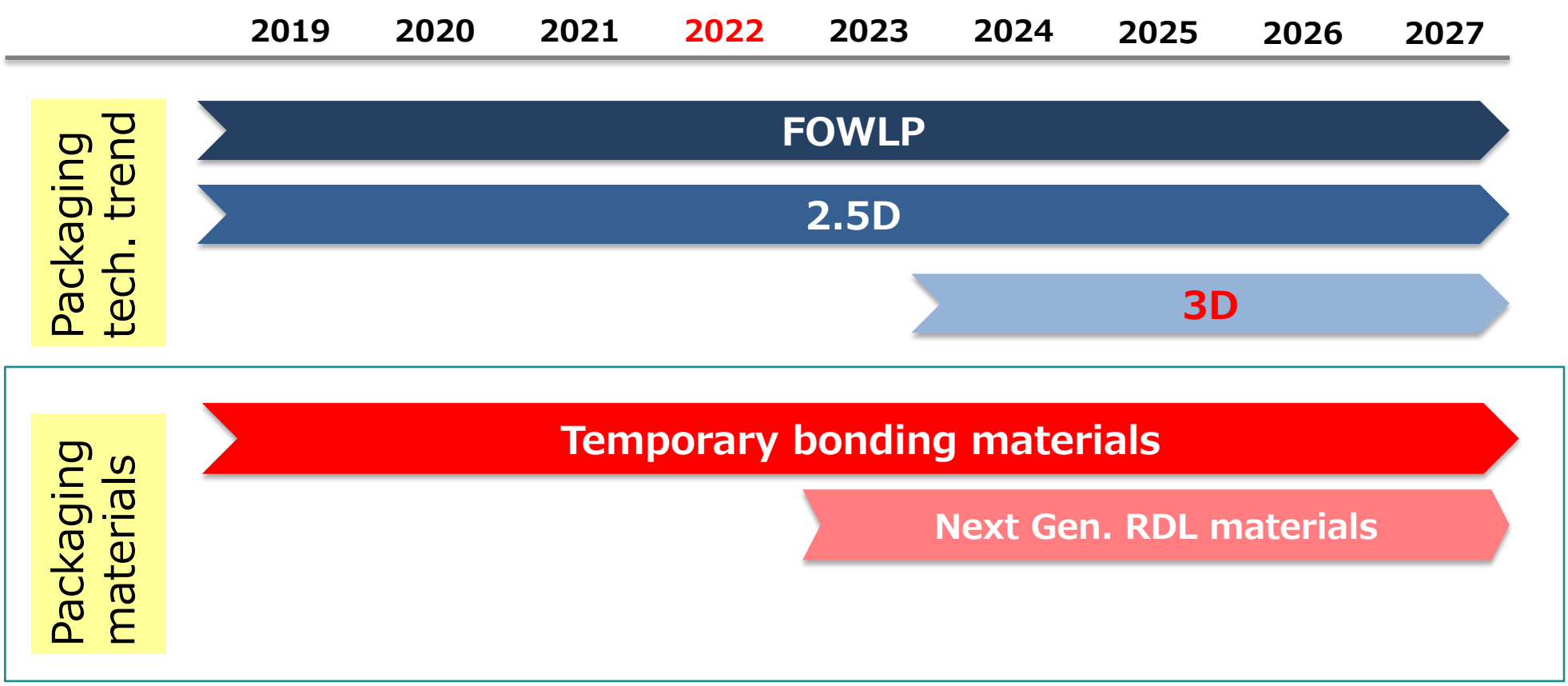
Source: Ministry of Economy, Trade and Industry
Semiconductor / Digital Industry Strategy 2021.6

Miniaturization Road Map



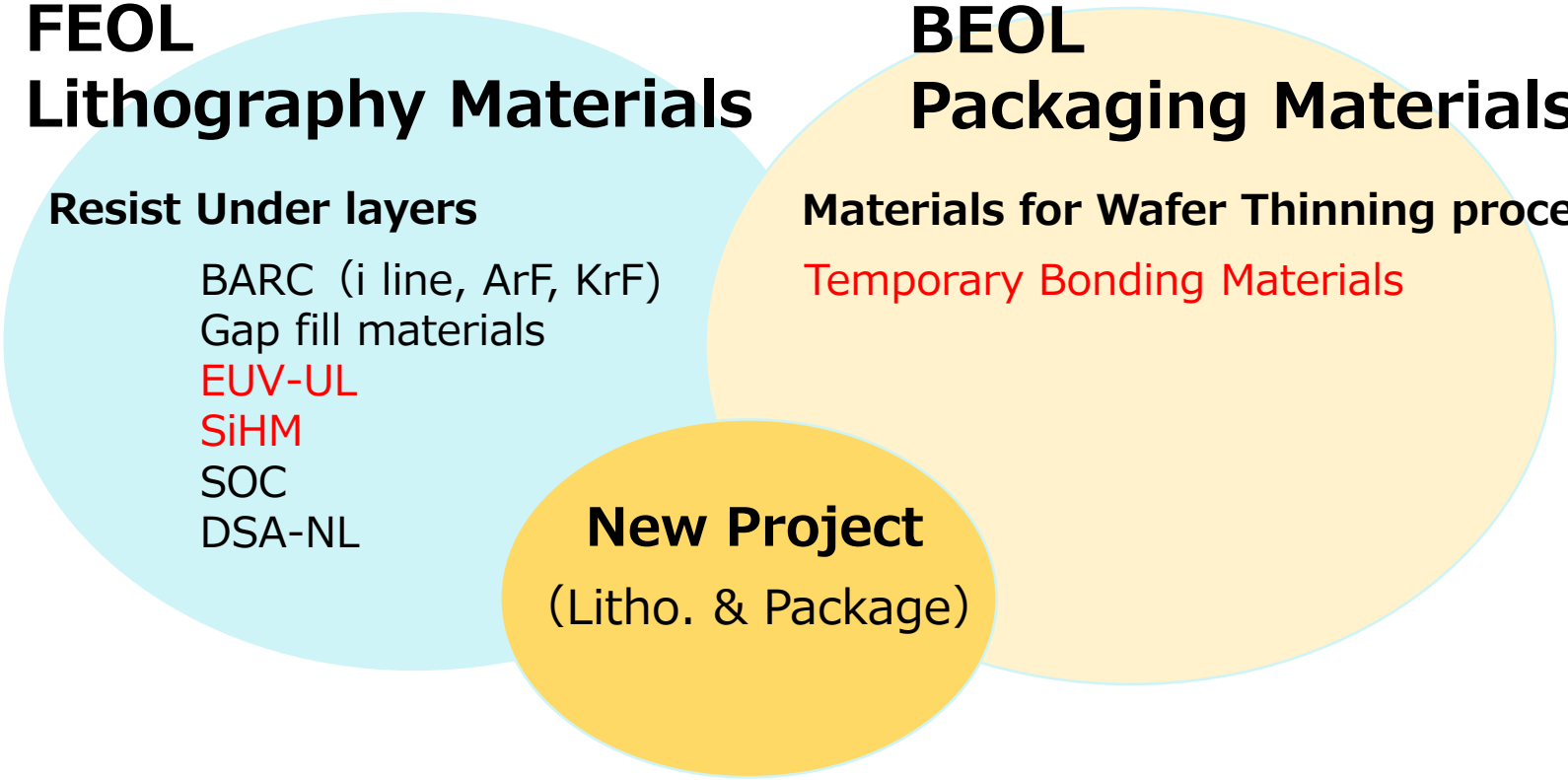
- **Miniaturization will continue up to 1nm node. （Mass production ~2025）**
- **EUV lead the miniaturization further.**

3D Packaging



Chip performance could be dramatically improved by combination of miniaturization and 3D integration.
Chiplet tech. can move forward the 3DIC market expand.

R&D for Semiconductor Materials



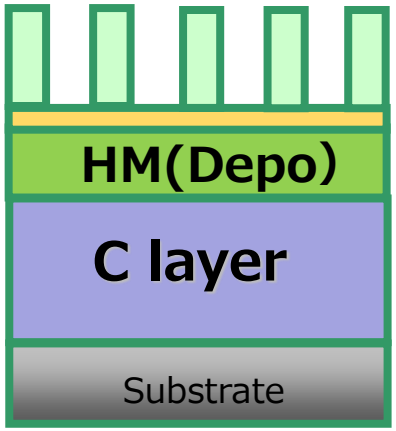
【R&D Strategy】

- **Focus to Resist Under layer materials based on Lithography road map（FEOL）**
- **Develop materials for wafer thinning process（BEOL）**
- **Finding new project based on our own technology in Litho. and packaging area**

Contents

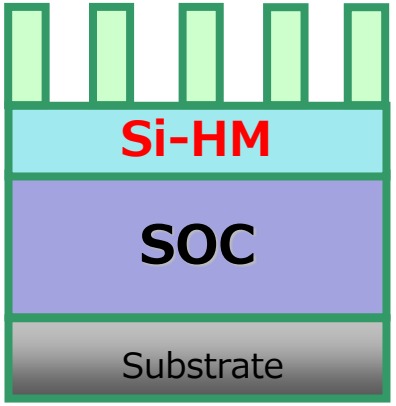
Lithography Materials (EUV-UL, EUV-SiHM)

4 layer process



EUV-UL

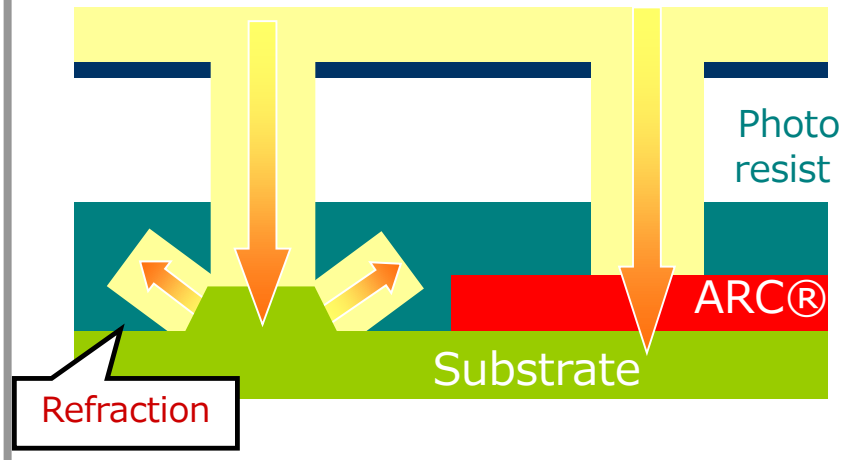
Tri layer process



EUV-UL (Under layer for EUV)

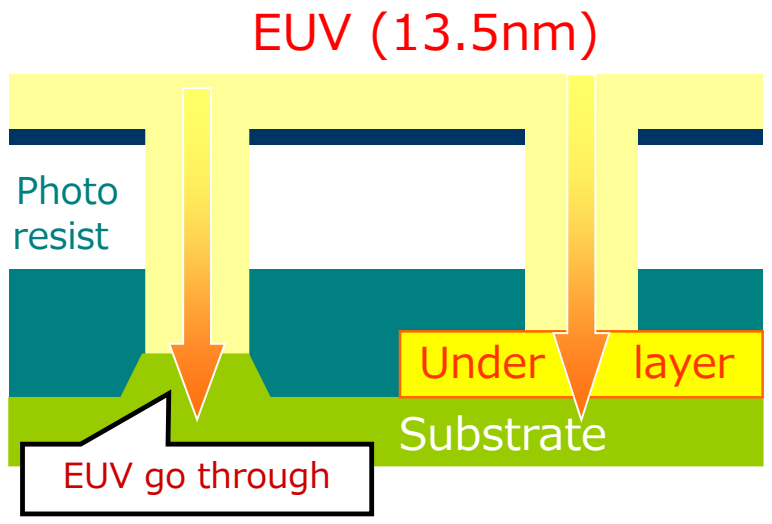
Optical and EUV Lithography

Optical Lithography



Anti-Refrective Coating (ARC®) is necessary to control the light reflection from substrate.

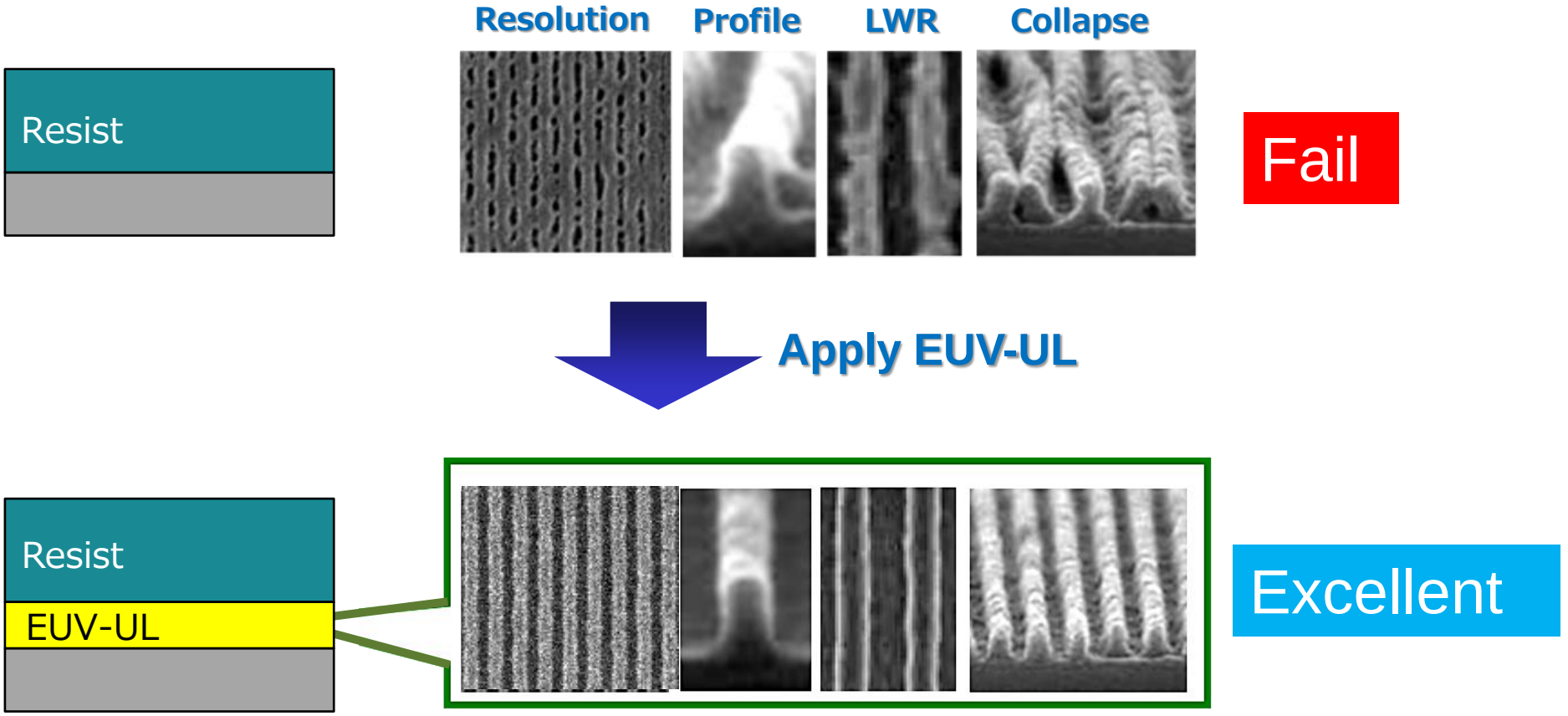
EUV Lithography



Anti-Refrective Coating (ARC®) is NOT necessary for EUV.
Because of no refection from sub.

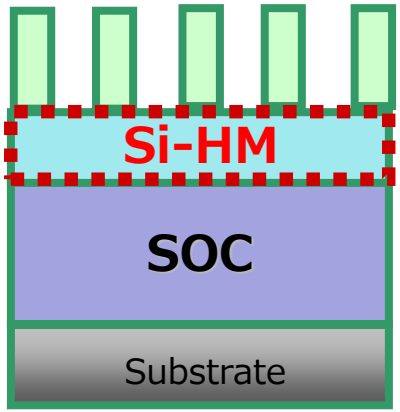
*ARC® is registered trade mark of Brewer Science, Inc.

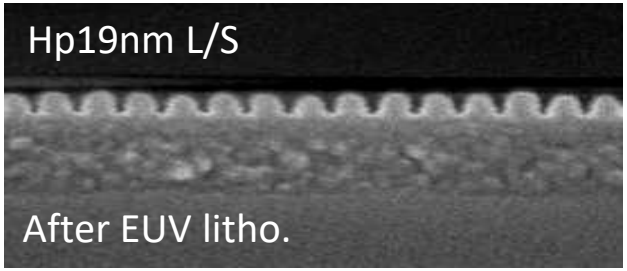
Lithography Performance



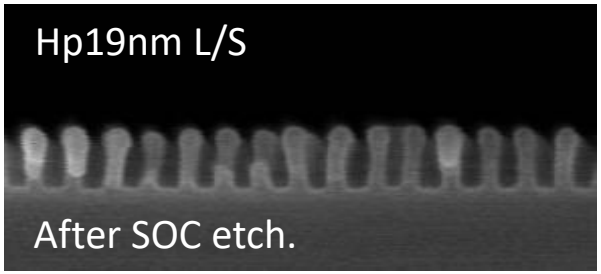
EUV-UL MUST BE necessary for EUV lithography
⇒ Applied for HVM

EUV-SiHM (Si Hard Mask for EUV)





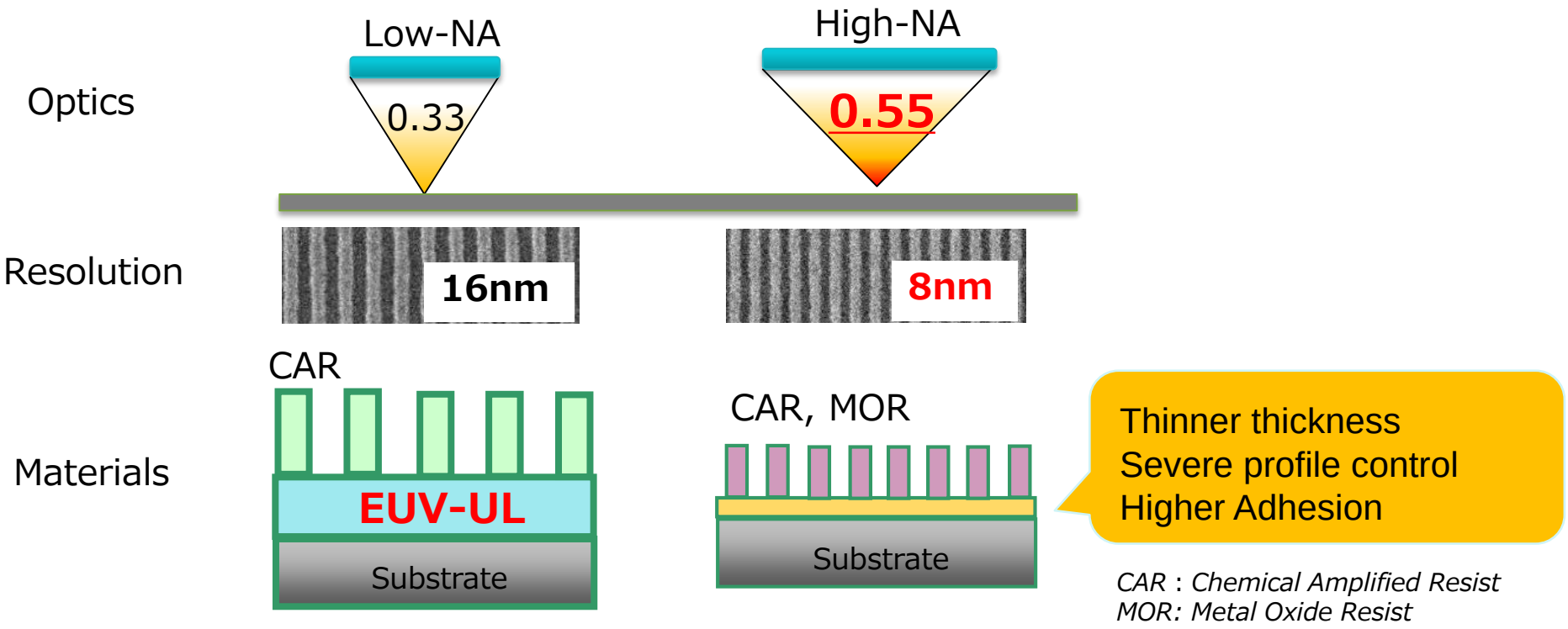
Good resist profile



Good etch performance

EUV-SiHM in TRL stack MUST BE necessary for EUV.
⇒ Applied for HVM

For High NA EUV



CAR : Chemical Amplified Resist
MOR: Metal Oxide Resist

Start R&D work at consortium
-For CAR : Improvement of Resolution and Process window
-For MOR : Development of MOR dedicated EUV-UL and SiHM.
⇒Target to be the de fact standard materials for high-NA EUV.

Contents

Temporary Bonding Materials

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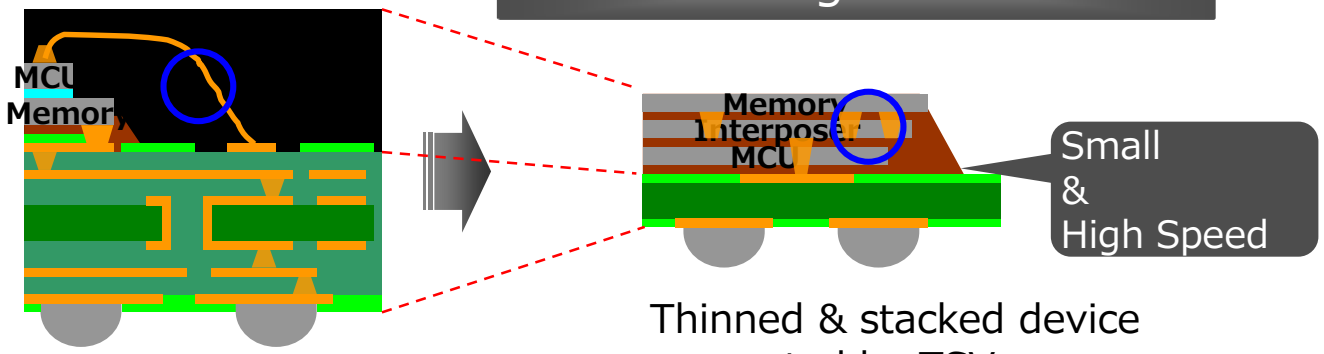
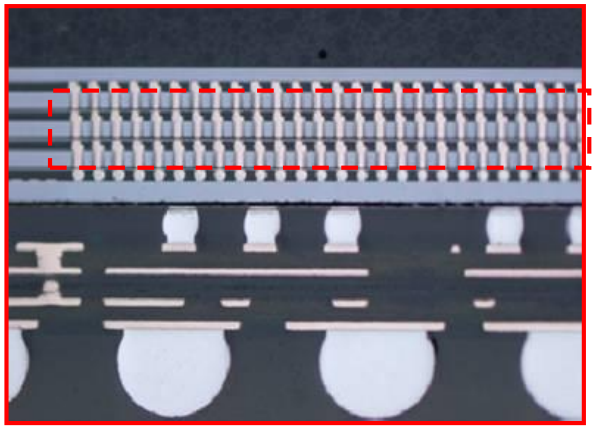
X section of device



Wire bonding to TSV

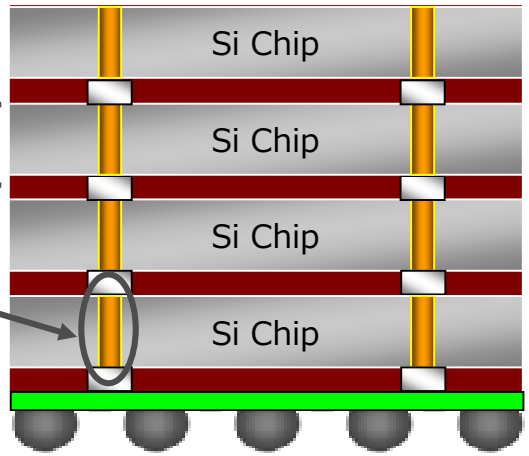
Thinned & stacked device connected by TSV



TSV (Through Silicon Via)

Challenge for TSV

- Thin down (< 50um)
- High Temp. process



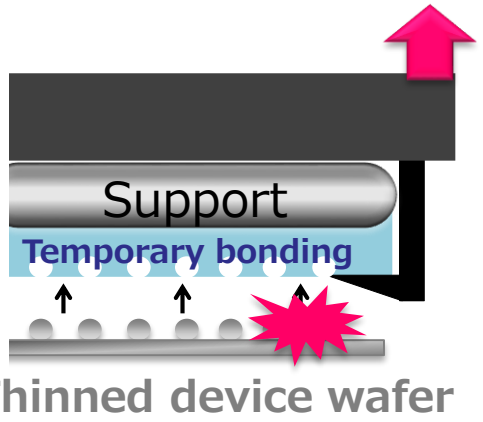
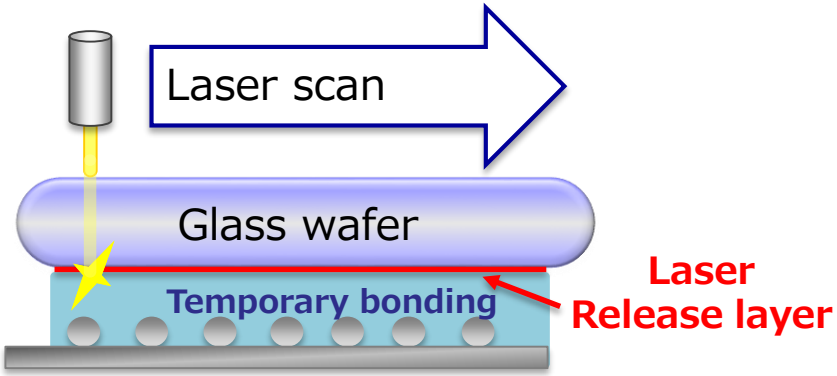
Special handling process and materials are necessary for wafer thin down process.

TWS

TWS (Thin Wafer Support System)

Type of Temporary Bonding

Laser type release layer will be required due to mechanical stress when wafer thickness will be thinner down.

	Mechanical de-bond	**Laser de-bond**
Image		
Merit	No limitation for Support wafer & CoO	No Mechanical stress
Challenge	Mechanical stress	Need Glass wafer for support

NCC have been developing temporary bonding material for Mechanical de-bond and Laser de-bond process.

Lineup for Temporary Bonding Materials

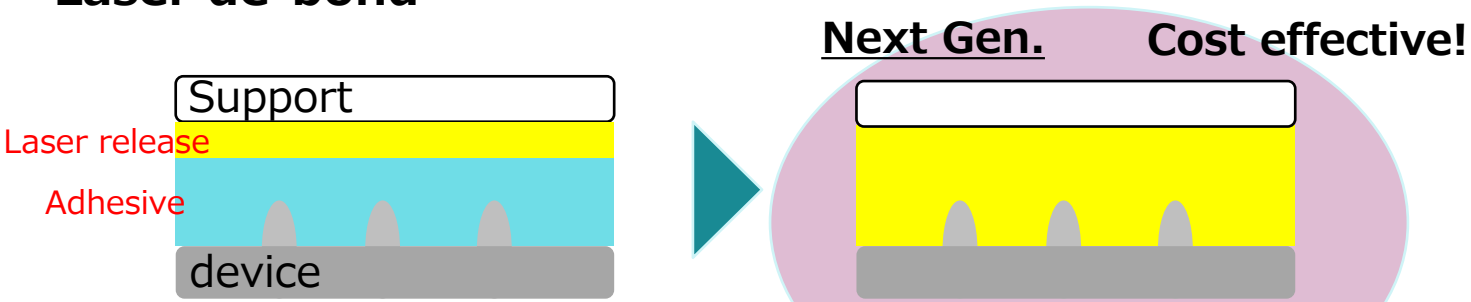
Mechanical de-bond

3 Layer
Product

1 layer
Product

1 layer
R&D

Laser de-bond



2 layer
Pilot stage

1 layer
R&D

NCC have Supported HVM in customer for ~HBM2 and developing next Gen. mechanical and laser de-bonding materials.

Display Materials

Contents

LC Alignment Materials

New products

Contents

LC Alignment Materials

New products

Strategy for Alignment Layers

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<u>To get high market share for growth fields</u>

- Alignment layers for TV
  →rubbing IPS and VA

- Keep high market share of photo IPS
  →expanded application
  compatible products for carbon-neutral

Strategy of Alignment Layers for Rubbing IPS

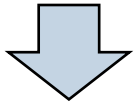
Nissan Chemical CORPORATION

✓ New materials for wider viewing angle and better image sticking

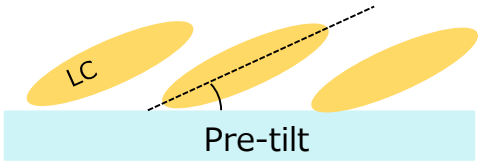
Rubbing process

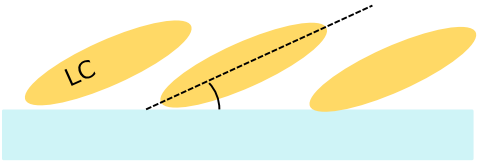
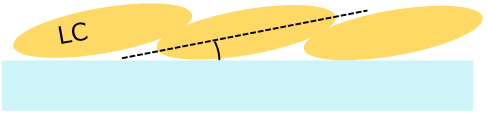
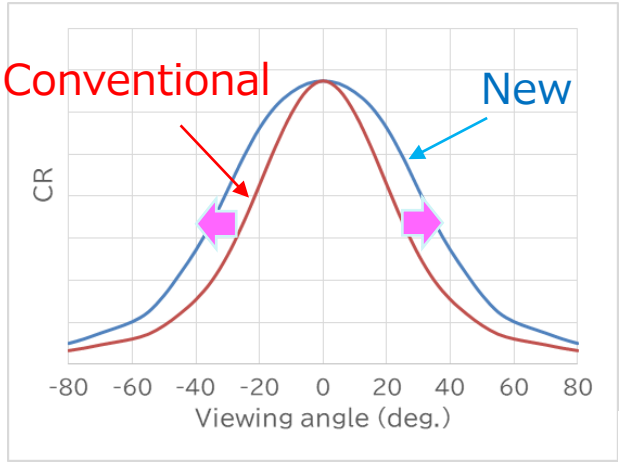
Rubbed alignment layer by cloth

Alignment layer



LC molecules align with pre-tilt.

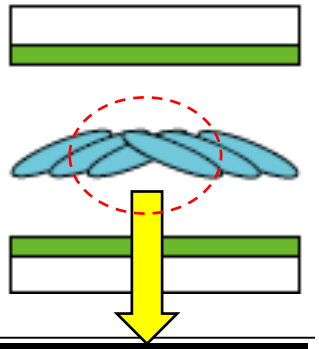
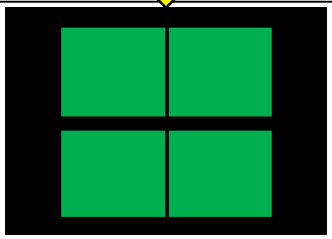


	Conventional	New
LC alignment	○	◎
Pre-tilt		
Viewing angle	 ※Simulation	

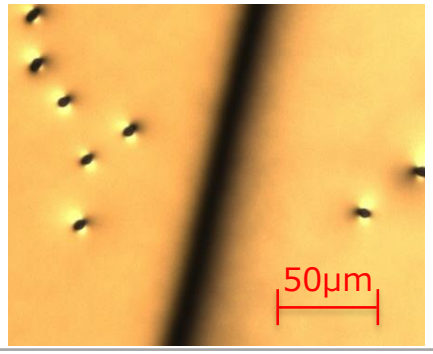
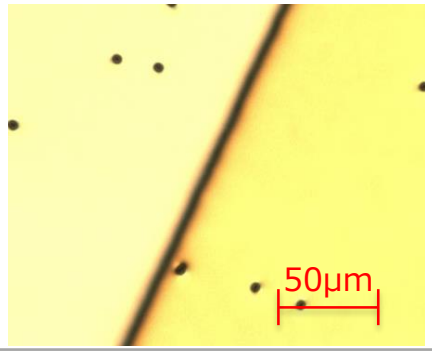
Strategy of Alignment Layers for Photo VA

Nissan Chemical CORPORATION

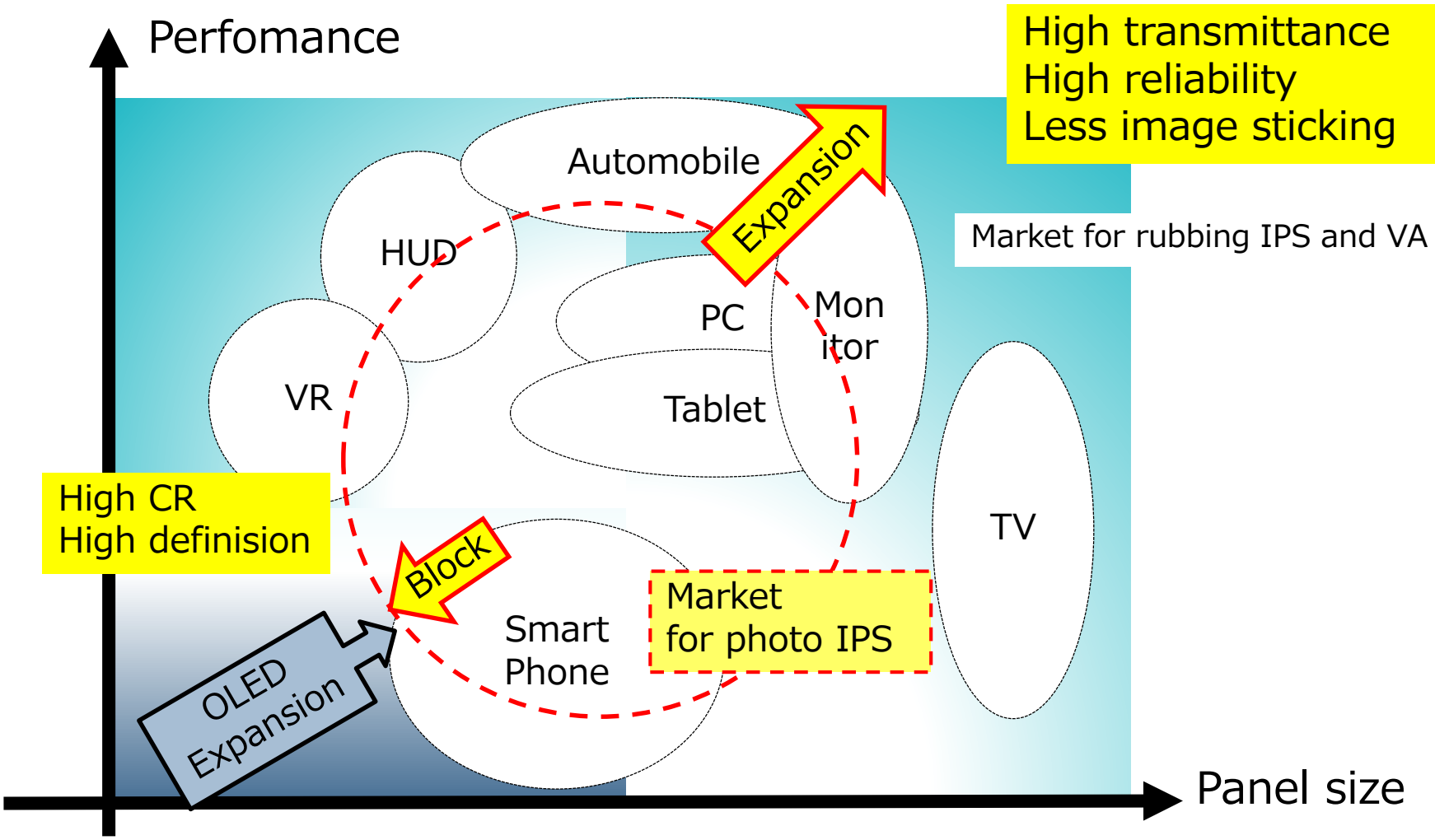
- ✓ New materials for higher transmittance photo VA-LCD
  - → new approach to narrow black line width

	Photo VA
Method	Photo alignment
LC alignment	
Voltage applied	

Black line generated at the boundary

	Conventional	New
Black line		
Transmittance	Low	High
CR	○	◎
Image sticking	○	○

Strategy for Expanding Application of Photo IPS



Environment Surrounding Display Business

- ✓ Active movement toward carbon neutrality
- ✓ Huge power needed to manufacture display panels

  →Large amount of carbon dioxide emissions
- ✓ Increased demand for carbon footprint reduction

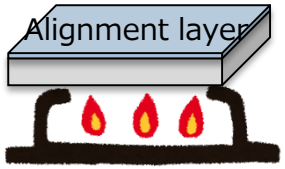
→Develop new materials that contribute to low power consumption

Strategy of Alignment Layers for Photo IPS

✓ Aim to replace with environmentally friendly materials

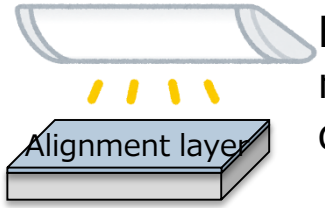
①Manufacturing process

Lower baking temperature



Energy consumption reduction of ovens

Lower UV dose



Energy consumption reduction of exposure devices

②LCD panel

High transmittance/Low driving voltage

Energy consumption reduction of back light and driving circuit

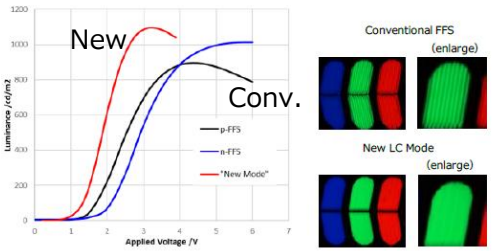


Fig. 2. Voltage-Transmittance characteristics and POM image at white state

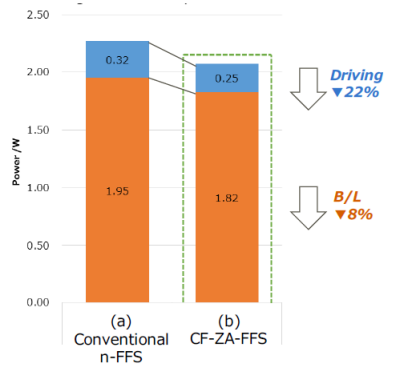


Fig. 6. Total power consumption of 14-inch FHD LCD modules at 60Hz white state for conventional n-FFS and CF-ZA-FFS (brightness: 500nits)

Source:H. Asagi, SID 2022 Digest, p337(2022)

Contents

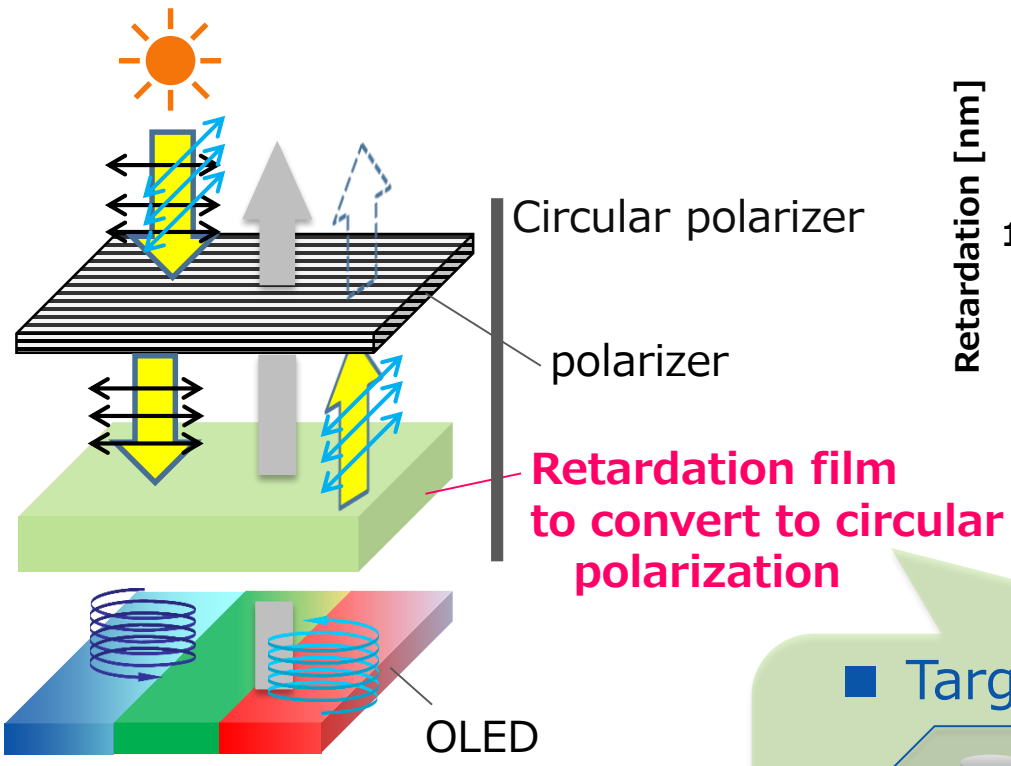
LC Alignment Materials

New products

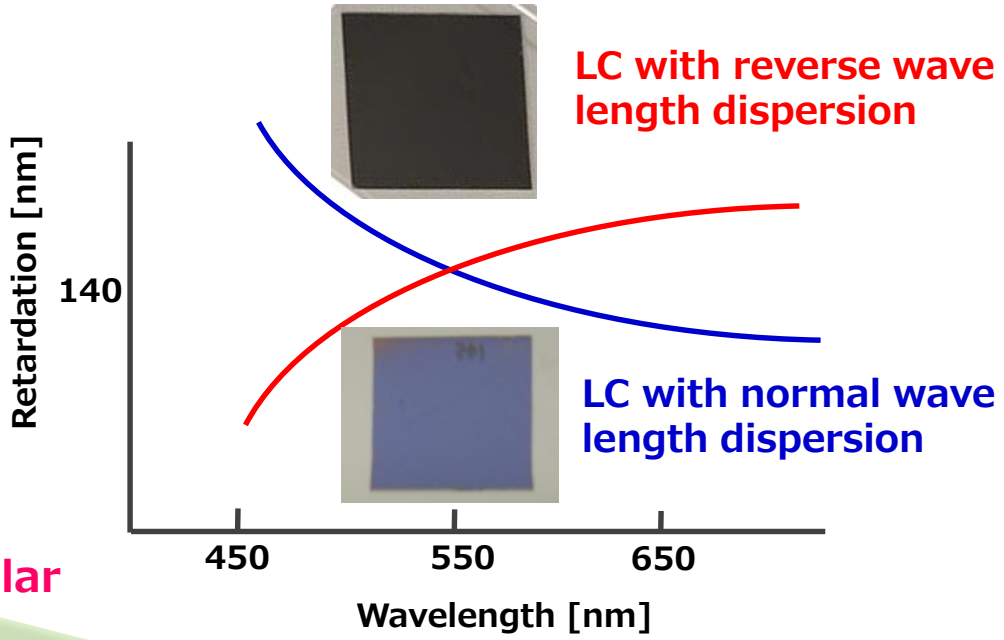
Photo Alignment Layers for Retardation Films

Nissan Chemical CORPORATION

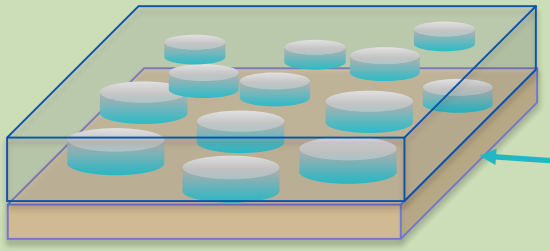
■ Circular polarizer



■ Wavelength dependence



■ Target ■



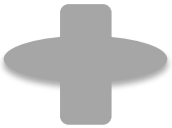
LC with reverse wave length dispersion

Photo alignment layer

Features of Our Materials

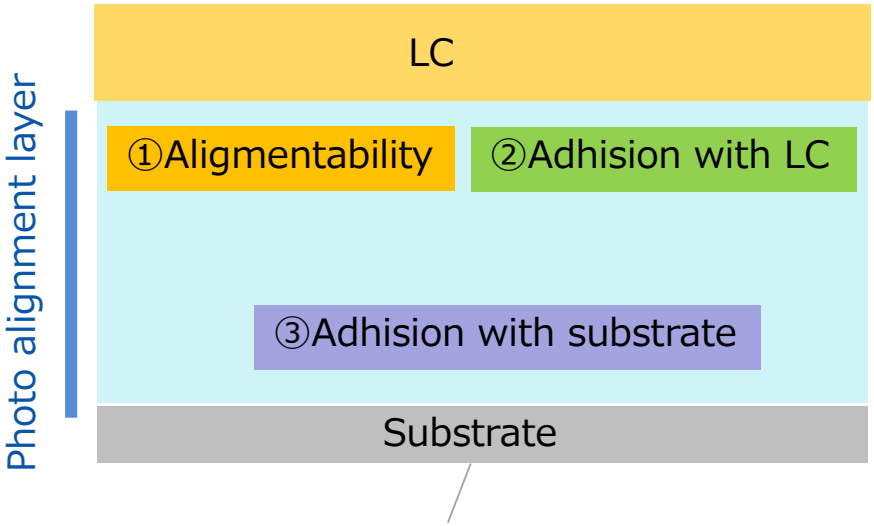
Point 1. Good alignmentability for LC with reverse wave length dispersion

conventional : rod-like



new : not rod-like → difficult to get LC alignment uniformity

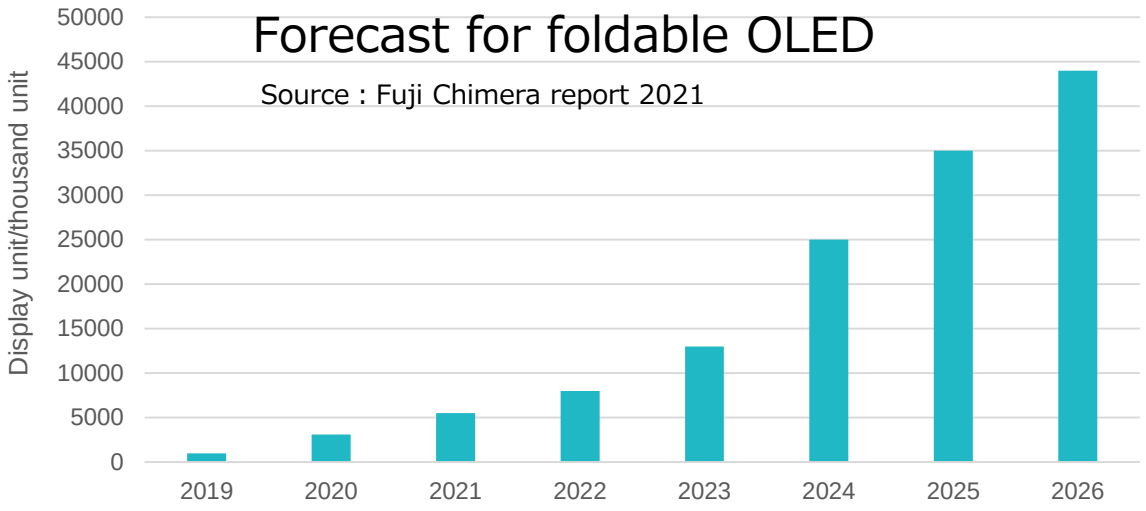
Point 2. Good compatibility for process and substrate



PET, TAC, acryl film, etc.

Possible to meet a variety of requests quickly

Hard Coating Material (HC) for Foldable Displays



Foldable smartphone

Source:Galaxy home page
https://www.galaxymobile.jp

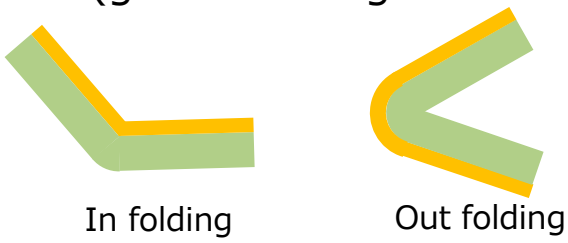
Our original surface control technology

Hard coating material

Protect Film

Film(PET, CPI…)

High stretchability
(good bending durability)



Slippery
Antifouling
Scratch resistance

Advanced Materials

Contents

Display Materials for OLEDs

- Hole Injection Layer
- Bank Material
- De-Bonding Layer
- Light Extraction Enhancement Material

Display Materials for Micro-LEDs

Contents

Display Materials for OLEDs

- Hole Injection Layer
- Bank Material
- De-Bonding Layer
- Light Extraction Enhancement Material

Display materials for Micro-LEDs

Strategy of Display Materials for OLED

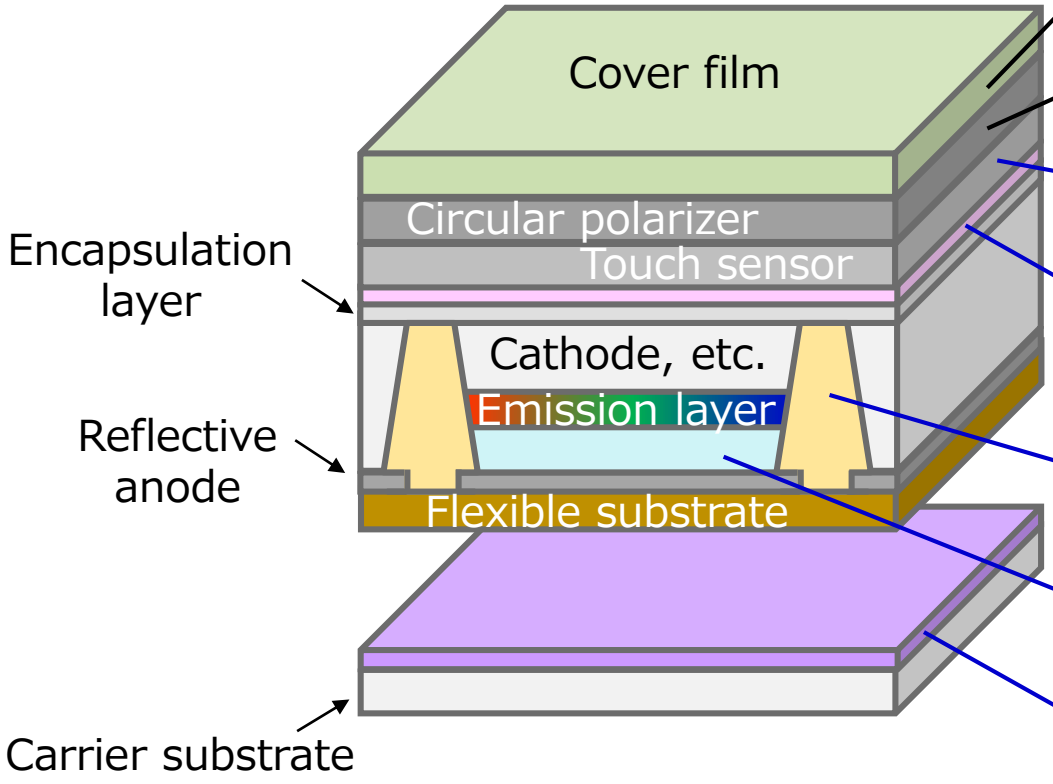
Materials for Eco-friendly processes & devices

- Next Gen. processes: **Hole Injection Layer**, **Bank Material**, **De-Bonding Layer**
- Next Gen. devices：**Light Extraction Enhancement Material**

Portfolio of Display Materials for OLEDs

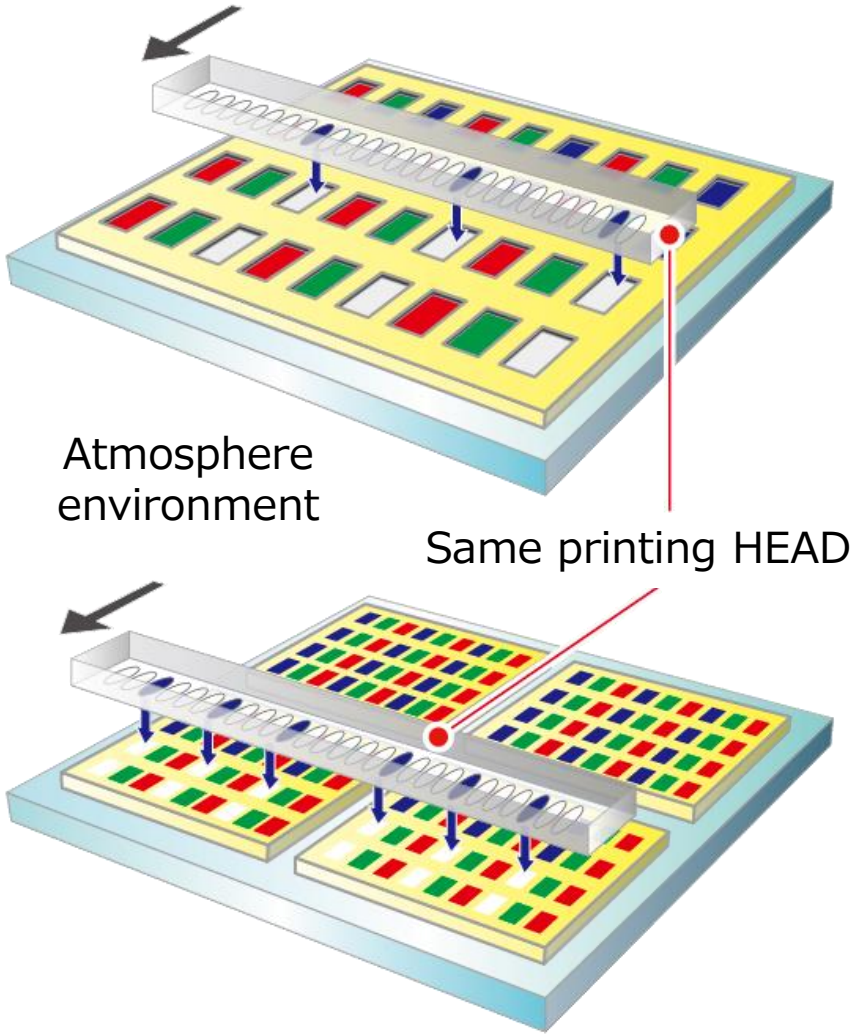
Nissan Chemical CORPORATION

Structure of Next Gen. OLED



- Hard Coating Material
- Retardation-film Material
- **De-Bonding Layer**
- **Light Extraction Enhancement Material**
- **Bank Material**
- **Hole Injection Layer**
- **De-Bonding Layer**

Printed OLED Process



(1) Printing process: use only required material and quantity

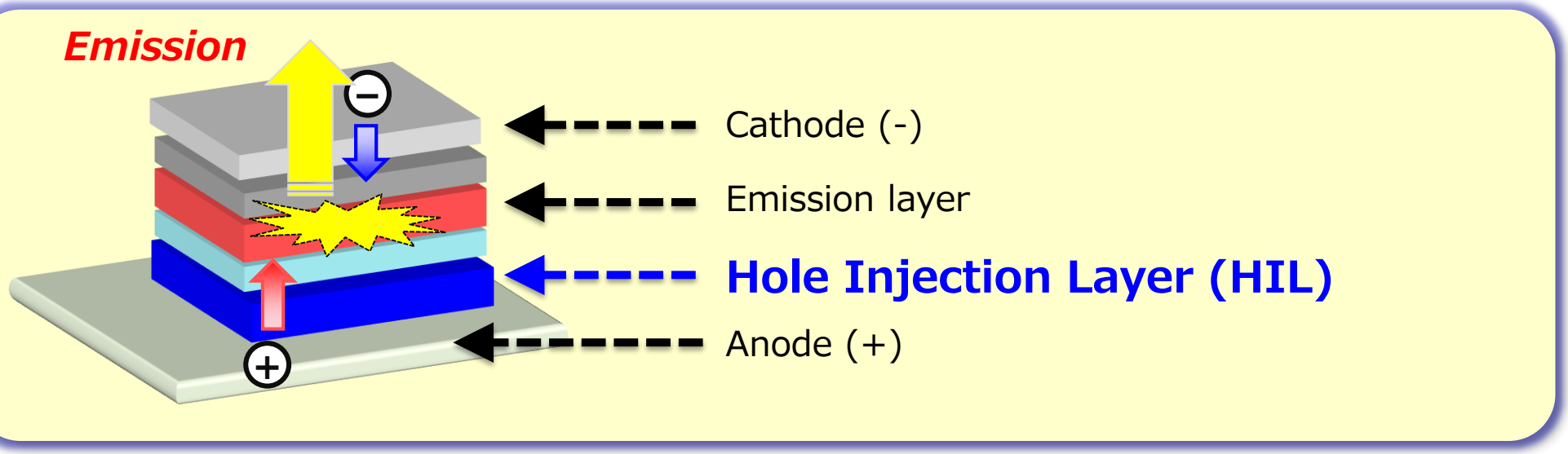
(2) Atmospheric environment: apply eco-friendly equipment

(3) Suitable for large-size substrates: metal mask less

➔ **Hole Injection Layer & Bank Material**

Source: JOLED, 2018
(https://www.j-oled.com/eng/technology/)

Hole Injection Layer (HIL)



Purpose

- Effectively inject hole to emission layer
- Optimize both hole injection efficiency and optical properties

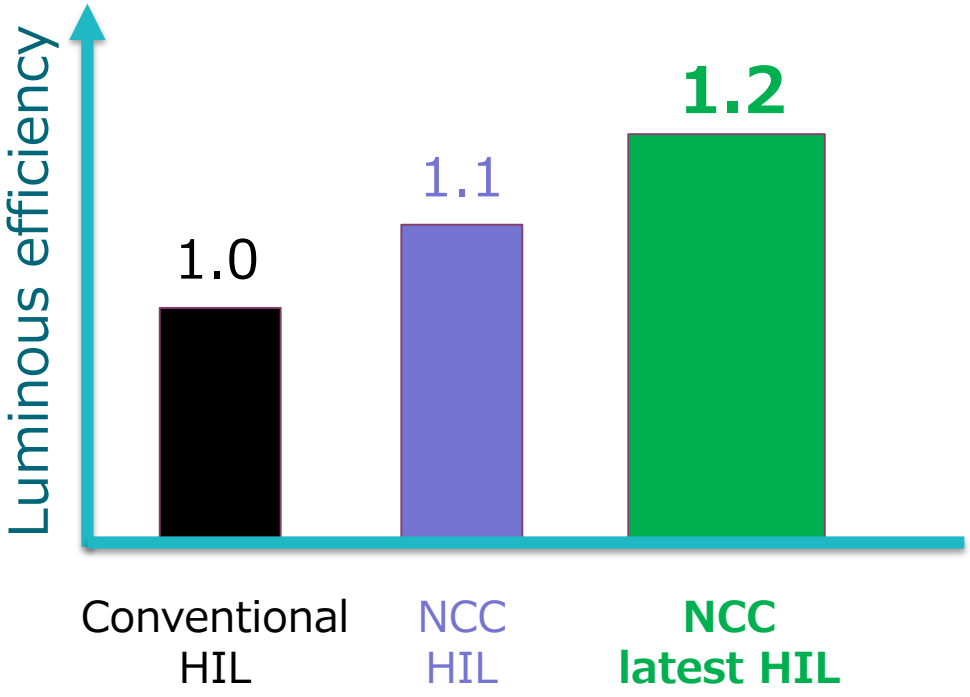
Features

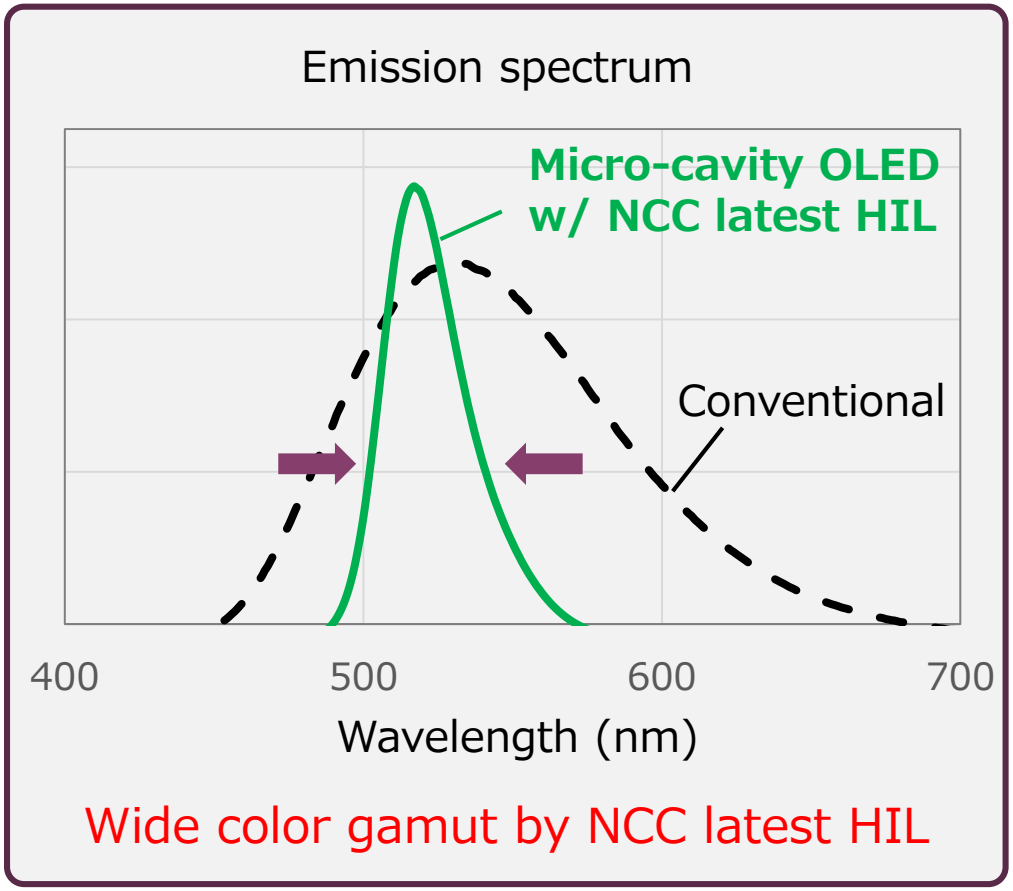
- Low power consumption
- Long life time
- Suitable to fit micro-cavity structure

HIL with well-controlled Refractive Index

Our approach

Electrical property/ High definition inkjet printing + World's largest control range of refractive index

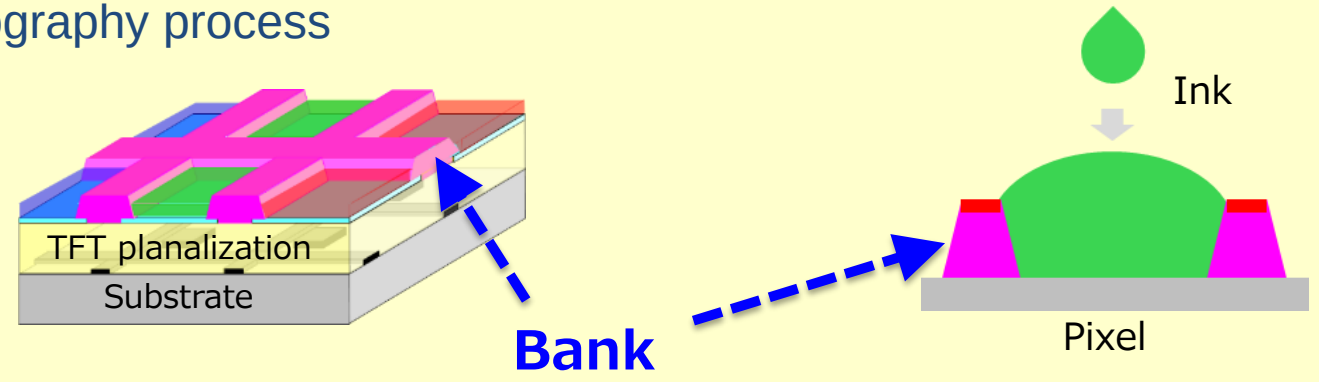




Wide color gamut by NCC latest HIL

Bank Material

Fabricate bank around pixel by photo lithography process



Purpose

- Ensure uniformity of inks in pixel area
- Hydrophobic bank surface to fit any device structures

Features

- Stable luminous property with bringing out the best in each layer
- Fine pitch patterning without color mixing
- High production yield

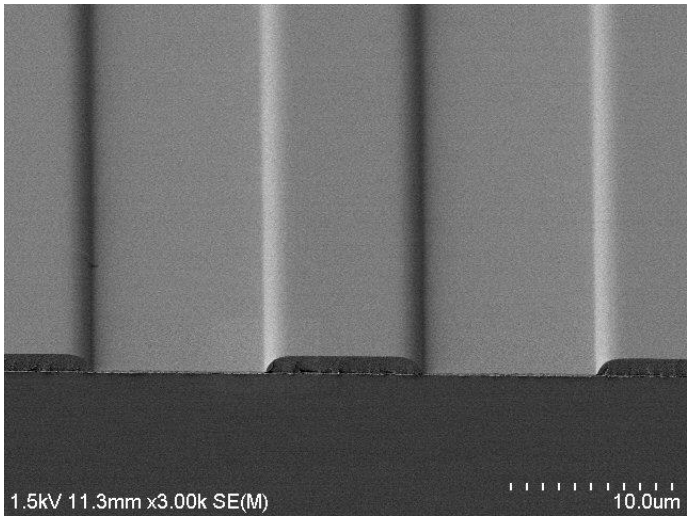
Hydrophobic Bank Material

Our approach

High resolution, high sensitivity, no residue (excellent wettability of inks), no out-gas

→ Fit to any device structures and pixel pitches

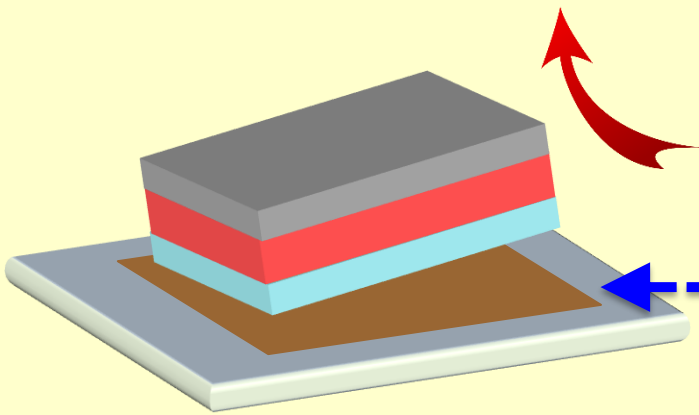
→ Maximum luminous efficiency combined with NCC HIL



SEM picture

Inkjet printing of NCC HIL at areas surrounded by banks

De-Bonding Layer (DBL)



Similar de-bonding force to adhesive portion of sticky note

De-Bonding Layer (DBL)

Purpose

- Coat de-bonding layer on carrier glasses for flexible displays
- Control de-bonding force to fit any device structures

Features

- Stable keeping & de-bonding forces
- Eco-friendly process with low running cost
- Re-use carrier substrates easily
- Can apply printing machines in current LCD Fabs.

DBL for Mechanical De-Bonding Process

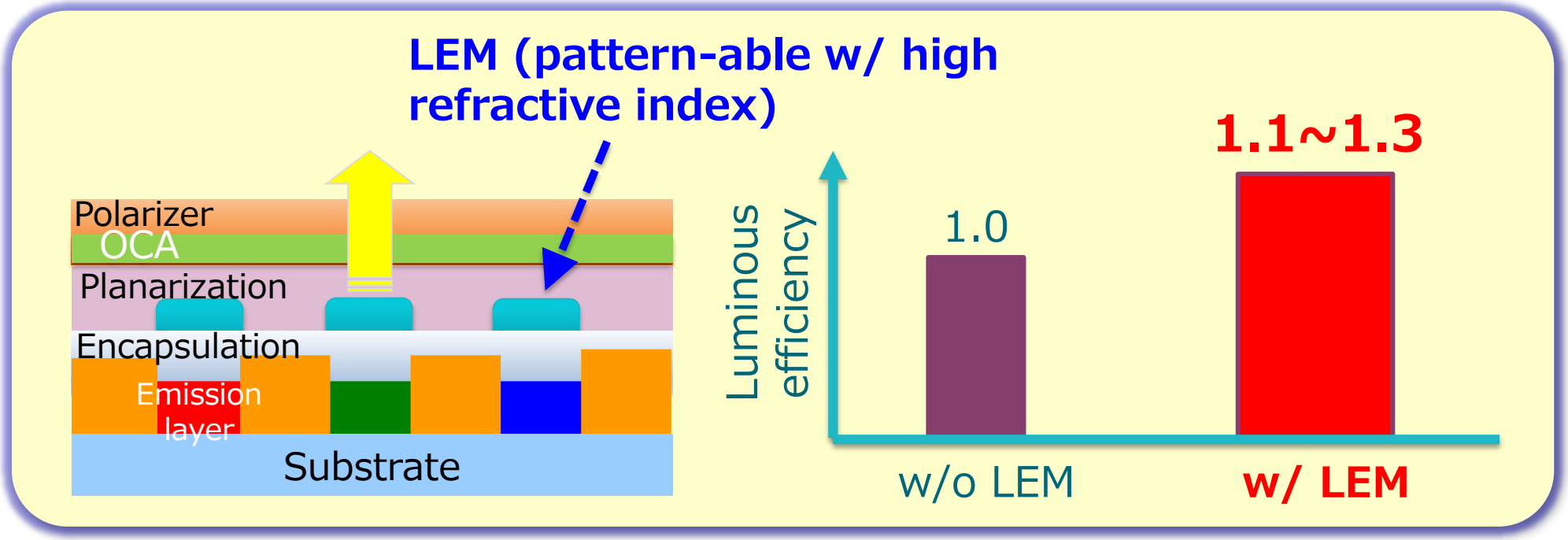
Our approach

- Excellent de-bonding properties to any film substrates
- Excellent heat resistance to fit any manufacturing processes

→ Differentiation to conventional laser lift-off process by the features of eco-friendly & low running cost

Items	Our DBL
Film substrates	Epoxy, Polyimide, etc.
Process temperature	180～450℃
Printing process	Spin coating, Slit coating, Flexographic printing, etc.

Light Enhancement Extraction Material (LEM)



Purpose

- Effectively out-coupling of emission light

Features

- 10~30% higher luminous efficiency→ Low power consumption
- Long life time

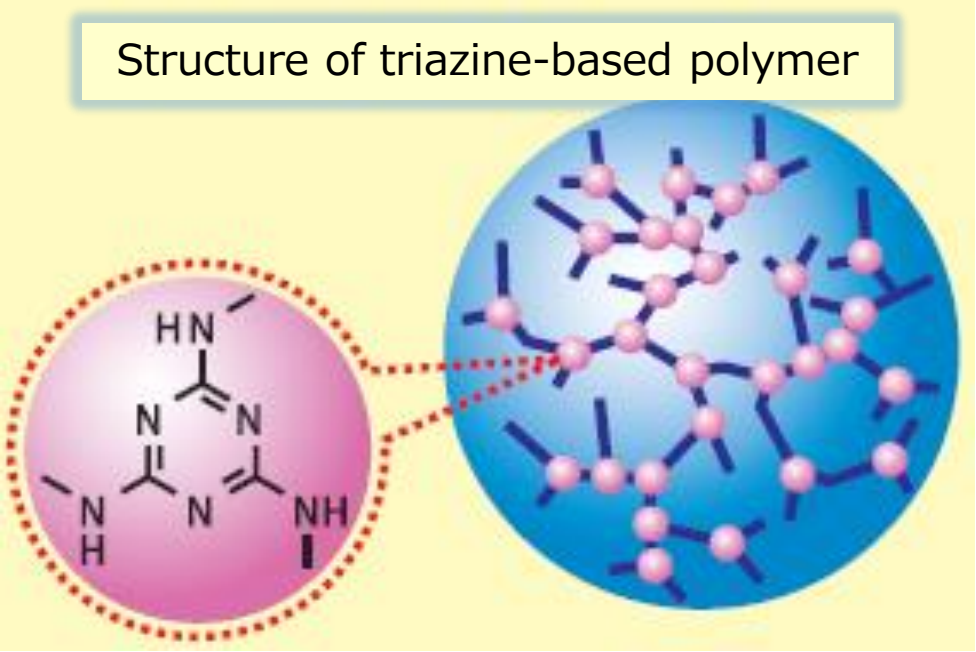
Triazine-based Polymer LEM

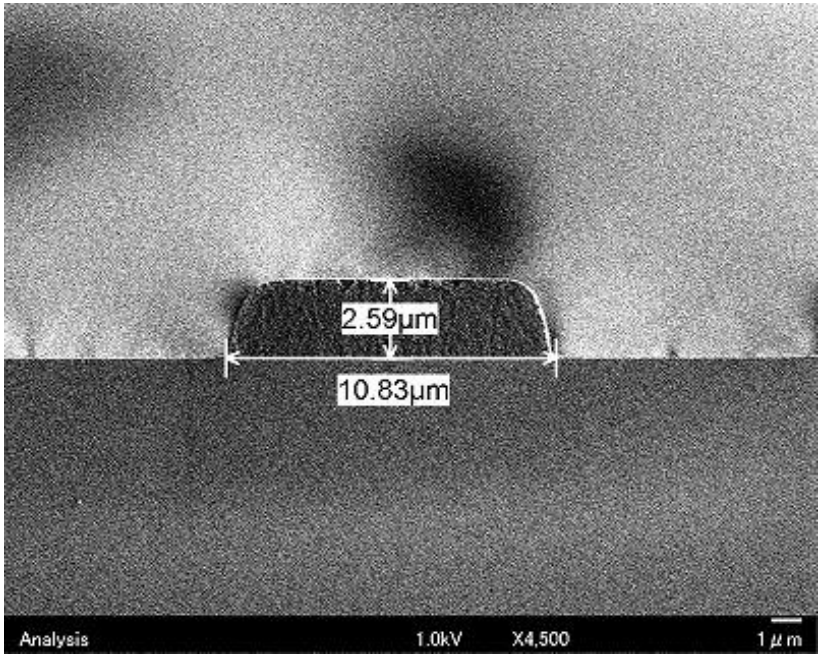
Our approach

Our original triazine-based polymer w/ high refractive index

→ Photo lithography without residue (both rectangular & lens)

→ Adjustable refractive index within the range from 1.5 to 1.9





SEM picture

Contents

Display Materials for OLEDs

- Hole Injection Layer
- Bank Material
- De-Bonding Layer
- Light Extraction Enhancement Material

Display Materials for Micro-LEDs

Strategy of Display Materials for Micro-LEDs

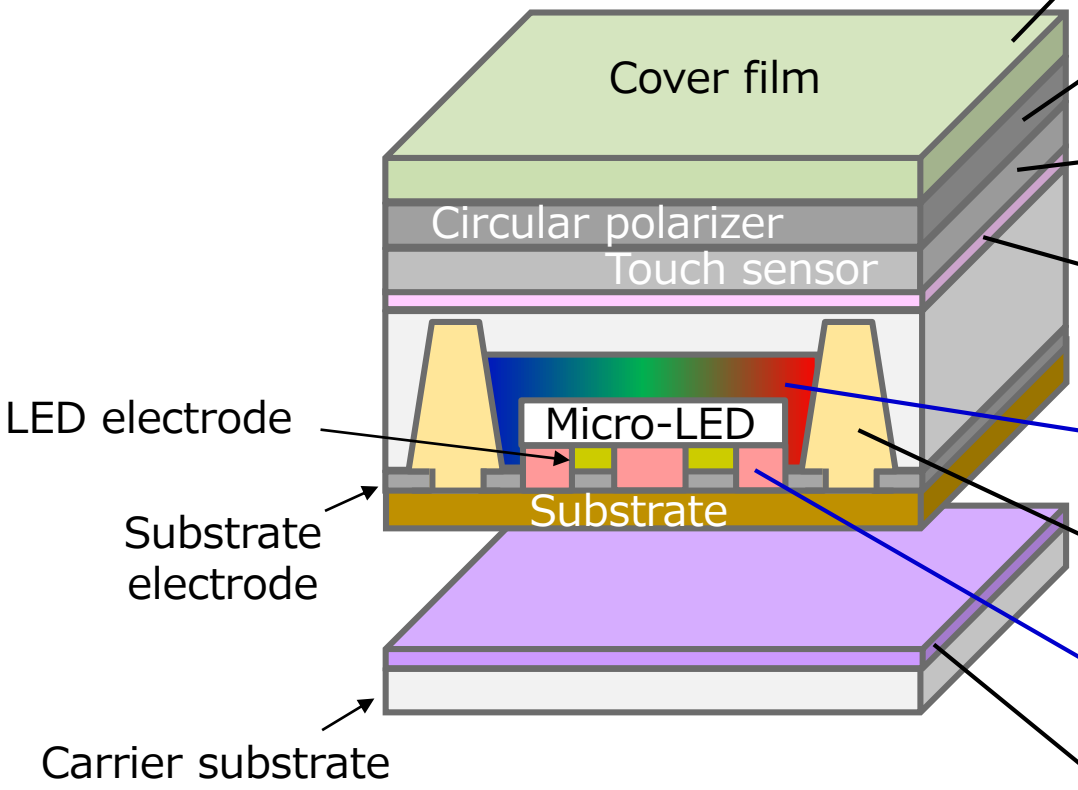
Materials for eco-friendly Micro-LEDs

- Wide color gamut: **Color Conversion Material**
- High reliability: **Under-Fill Material**

Portfolio of Display Materials for Micro-LEDs

Nissan Chemical CORPORATION

Structure of Micro-LED



- Hard Coating Material
- Retardation Film Material
- De-Bonding Layer
- Light Extraction Enhancement Material
- **Color Conversion Material**
- Bank Material
- **Under-Fill Material**
- De-Bonding Layer

Inorganic Materials

Contents

Inorganic Colloid Materials

Development of Environmentally Friendly Materials

Contents

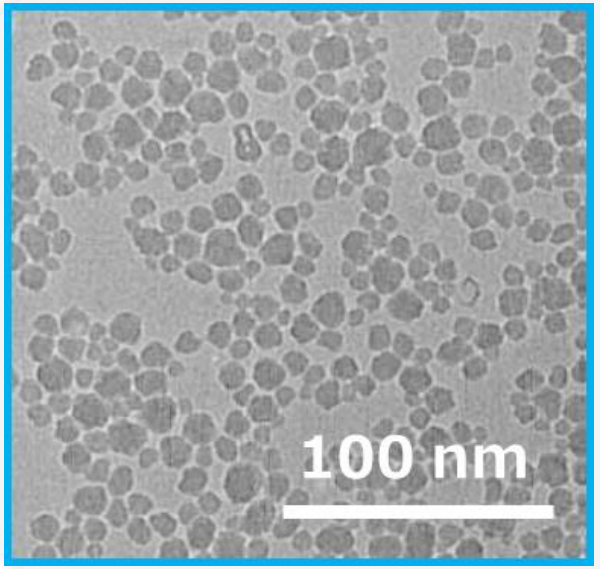
Inorganic Colloid Materials

Development of Environmentally Friendly Materials

What is an Inorganic Colloidal Material?

A material in which nano-sized fine particles are dispersed in a solvent (water, organic solvent, monomer).

Typical product “ SNOWTEX-30 "



Nanoparticles of Silica sol

Particle size ： 12 nm

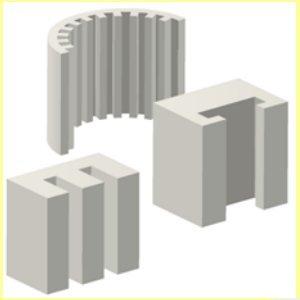
Solid content ： 30 wt%

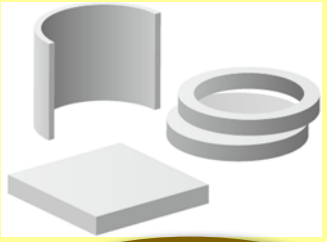
⇒15×10^16 count/g

Applications of Our Materials

Casting
(mold)

Ceramics





Binder
Heat resistance

Catalyst

SNOWTEX®
ORGANOSILLCASOL
ALUMINASOL
NanoUse®
SUNCOLLOID®

Coating

Polishing

Development Policies

Research materials (value) that will continue into the future

… Respond to market & needs

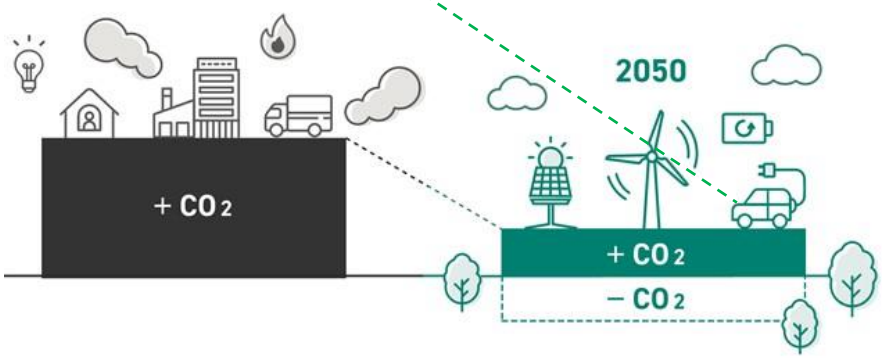
- Quality control
  Characteristics & purity, etc.
- Surface modification
  Dispersity
  Hydrophilic / Hydrophobic
  Reaction field
  Charge
- Function control
  composition
  structure
- Particle morphology control
  Size
  Distribution
  Shape

Technology and materials platform

Carbon neutrality

Motors

環境省HPより



Apply to environmentally friendly materials

Contents

Inorganic Colloid Materials

Development of Environmentally Friendly Materials

Nissan Chemical CORPORATION

■ Movement to achieve carbon neutrality

CO_2 reduction :

① **Related to Electric vehicle (EV)**

CO_2 storage / utilization :

② **Related to CCS / CCUS※**

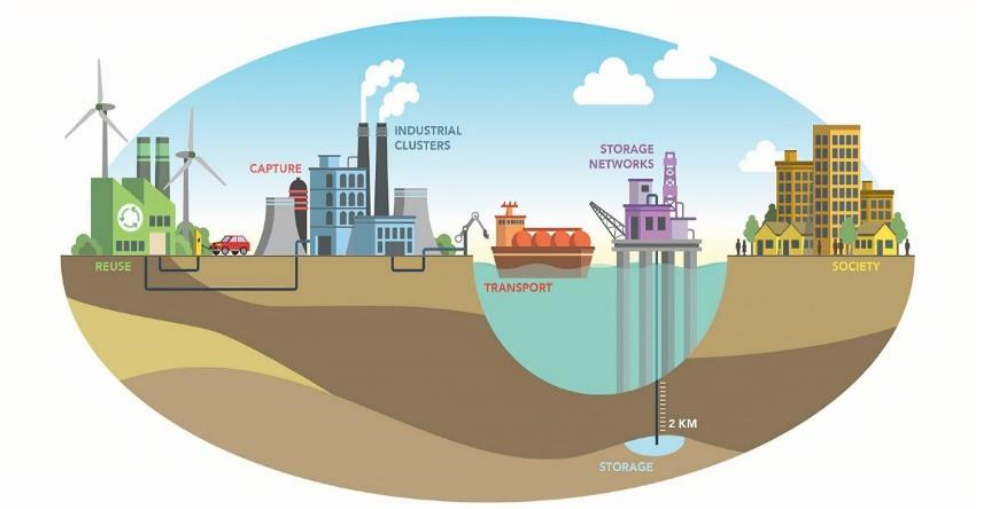
※Carbon dioxide Capture, Utilization and Storage

EV/TESLA

EV/BYD

Motors

Enameled wire

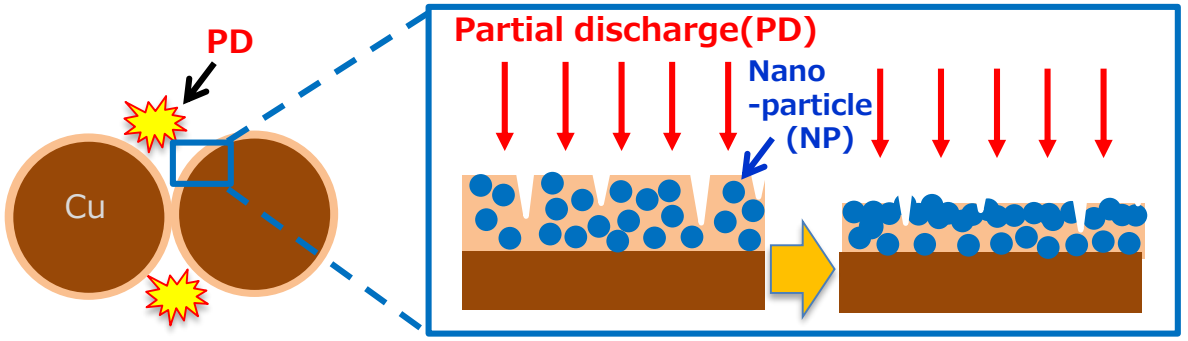


Insulation Material for Enameled Wire （1）

Nissan Chemical CORPORATION

✓ Higher output/more compact EV motors

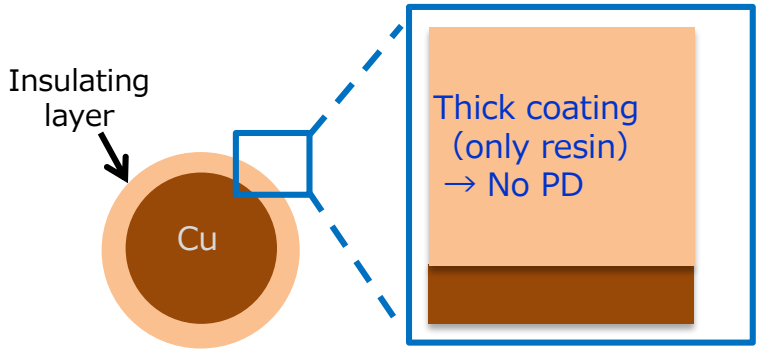
Surge-resistant enameled wire (w/NP)



Coating thickness
30～50μm

Nanoparticles inhibit erosion by partial discharge

High PDIV enameled wire



Coating thickness
100～150μm

Advantages of Surge-resistant type :

- **High allowable voltage**
- **High copper wire occupancy**

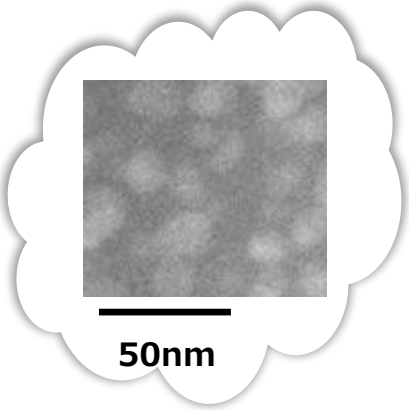
⇒ **Higher output and smaller motor**

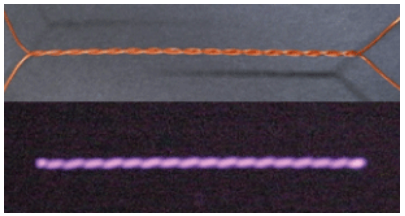
Enameled wire	Surge-rst	High-PDIV
Compositon of insulating layer	PI+NP	low-d PI
Higher output	++	+
Smaller size	++	+
Insulation lifetime	+	++

Insulation Material for Enameled Wire （2）

✓ Improvement of nanoparticles

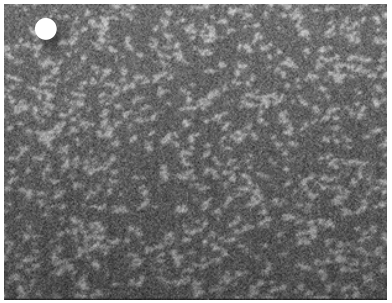
Nanoparticle → Insulating varnish → Enameled wire



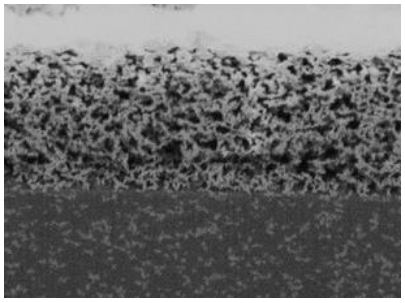


✓ Nanocomposite & Insulation evaluation

PI/silica nanocomposite

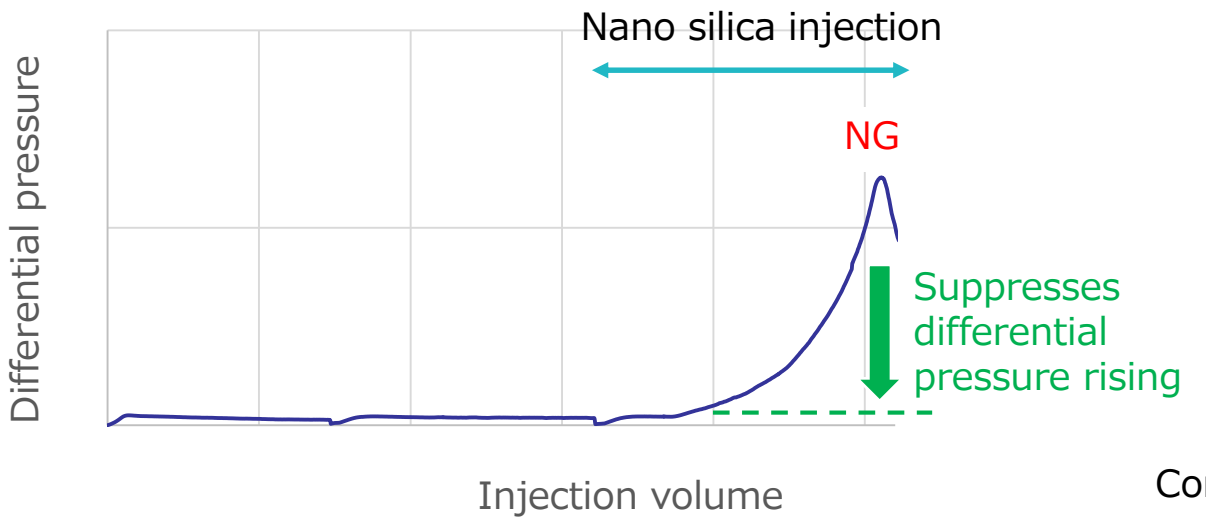


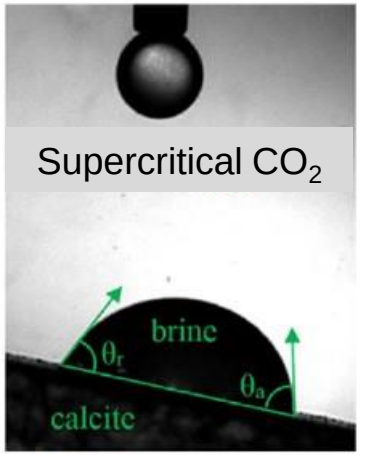
Enameled wire evaluation



✓ Fusion of nanoparticles and surface chemistry

Development of nanoparticle fluid		Expected function
Dispersibility (salt tolerance)	Stable under formation condition	No clogging in the injection process (No pressure rising)
Interfacial tension	Controlled to the same level as salt water	Leakage suppression of CO_2
Contact angle	Wettability modification of rock surface	Increasing CO_2 storage





Contact angle measurement

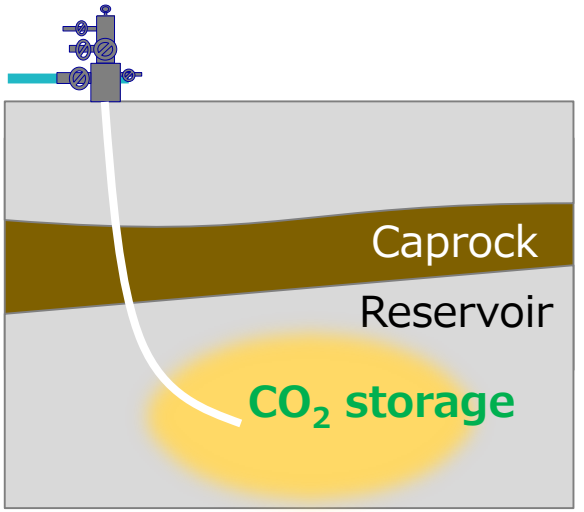
New Development （2）

✓ Collaboration with development partners

CCS(Carbon dioxide Capture and Storage) :

Collaborate with the Australian national research institute and a university

Started development of new materials that can significantly increase CO_2 storage

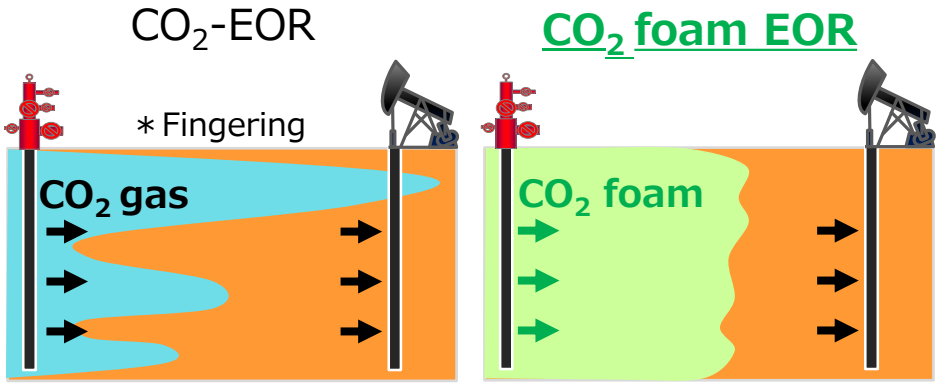


CCUS(Carbon dioxide Capture, Utilization and Storage) :

To solve existing CO_2 EOR issues *

Developed a new material to stabilize CO_2 foam

Planning a field test with a domestic oil company and a university this year



Fin.

Thank you for your attention.

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